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Results of the First Two Years of Commercial Operation of an Organic-Acid-Enhanced FGD (Flue Gas Desulfurization) System

Radian Corp., Austin, TX

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RESULTS OF THE FIRST TWO YEARS OF COMMERCIAL OPERATION OF AN ORGANIC-ACID-ENHANCED FGD SYSTEM

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16. ABSTRACT The report documents the first 2 years (1982 and 1983) of commercial operation of the dibasic acid (DBA) system at Springfield's Southwest Power Plant (SWPP), during which SWPP averaged an SO2 emission rate of less than 1.0 lb SO2/million Btu. (NOTE: EPA has sponsored research to develop organic-acid-enhanced flue gas desulfurization (FGD) technology for existing and new coal burning facilities. A 1981 EPA-sponsored demonstration program at SWPP, near Springfield, MO, showed that adipic acid and DBA greatly enhanced FGD performance. SWPP has continued to use DBA to comply with the 1971 SO2 emissions standard under which they are regulated. Thus, SWPP became the first commercial-scale system to use an organic additive to enhance SO2 removal.) At SWPP in 1980 (before DBA addition), SWPP averaged about 5 lb SO2/million Btu. FGD system reliability was also greatly improved, averaging 97.9% in 1982 and 98.7% in 1983, compared to 45% in 1980. The SO2/O2 continuous emissions monitoring system also showed excellent reliability, exceeding 97%. Overall, DBA has increased the flexibility of the SWPP system and, most importantly, allowed SWPP to operate in compliance.

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Dibasic Organic Acids	Stationary Sources	07C
Flue Gases		21B
Desulfurization		07A, 07D
Sulfur Oxides		07B
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ABSTRACT

The U. S. Environmental Protection Agency (EPA) has sponsored research to develop organic-acid-enhanced flue gas desulfurization (FGD) technology for existing and new coal burning facilities. A 1981 EPA-sponsored demonstration program at Springfield City Utilities Southwest Power Plant (SWPP), located near Springfield, Missouri, showed that adipic acid and dibasic acid (DBA) greatly enhanced FGD performance. SWPP has continued to use DBA to achieve compliance with the 1971 SO_2 emissions standard under which they are regulated. Thus, SWPP became the first commercial-scale system to use an organic additive to enhance SO_2 removal.

This report documents the first two years (1982 and 1983) of commercial operation of the DBA system at SWPP. During 1982 and 1983, SWPP averaged an SO_2 emission rate of less than 1.0 lbs SO_2/MM Btu. Conversely, in 1980 (prior to DBA addition), SWPP averaged approximately 5 lbs SO_2/MM Btu. FGD system reliability was also greatly improved averaging 97.9 percent in 1982 and 98.7 percent in 1983. These reliability figures compare to 45 percent reliability in 1980. The SO_2/O_2 continuous emissions monitoring system also exhibited excellent reliability exceeding 97 percent. Overall, DBA has increased the flexibility of the SWPP system and, most importantly, allowed SWPP to operate in compliance.

CONTENTS

		Page
ABSTRACT		iii
TABLES		v
FIGURES		v
1.0	SUMMARY	1-1
	1.1 Background	1-1
	1.2 Program Objectives	1-2
	1.3 FGD System Description	1-3
	1.4 Program Results	1-5
	1.5 Conclusions	1-6
2.0	INTRODUCTION	2-1
	2.1 Background	2-1
	2.2 Program Objectives	2-2
3.0	FGD SYSTEM DESCRIPTION	3-1
	3.1 Limestone Preparation Facility	3-1
	3.2 Scrubber Modules	3-4
	3.3 Solids Dewatering	3-5
	3.4 Dibasic Feed System	3-6
4.0	ANALYSIS OF PROCESS CONDITIONS	4-1
	4.1 Background	4-1
	4.2 Scrubber Performance	4-1
	4.3 DBA Consumption	4-5
	4.4 Equipment Inspection and Reliability	4-6
5.0	DATA ACQUISITION	5-1
	5.1 Continuous Emissions Monitoring System	5-1
	5.2 CEMS Reliability	5-2
	5.3 Quality Assurance	5-5
	5.4 Ability of CEMS to Meet NSPS Requirements	5-7
6.0	REFERENCES	6-1
APPENDIX A - SWPP WEEKLY COAL ANALYSES		A-1
APPENDIX B - SUMMARY OF FGD SYSTEM PERFORMANCE IN 1982		A-2
APPENDIX C - CONTINUOUS SO_2 EMISSIONS MONITORING RESULTS		A-3

TABLES

Number		Page
3-1	SWPP Average Monthly Coal Analyses for 1982	3-2
3-2	SWPP Average Monthly Coal Analyses for 1983	3-3
3-3	Typical Composition of Monsanto AGS Dibasic Acid (Dry Basis)	3-7
3-4	Typical Composition of DuPont Dibasic Acid (Dry Basis)	3-7
4-1	Summary of 1982 DBA Consumption Rates at SWPP	4-6
4-2	SWPP FGD System Reliability in 1982 and 1983	4-9
5-1	Summary of 1982 CEMS Reliability	5-4
5-2	Results of Method 6 Testing at SWPP on 19 August 1982	5-6

FIGURES

Number		Page
1-1	SWPP FGD Flow Scheme	1-4
3-1	SWPP FGD Flow Scheme	3-1
3-2	DBA Flow Schematic Temporary System	3-8
3-3	Solubility of DBA in Water	3-10
3-4	DBA Flow Schematic Permanent System	3-11
4-1	Comparison of SWPP Monthly Average SO_2 Emission Rates; 1980 vs. 1982 and 1983	4-3
4-2	Comparison of SO_2 Removal Efficiencies; 1980 vs. 1982 and 1983	4-4
5-1	Location of Continuous Monitors and Sample Ports at SWPP	5-2

SECTION 1

SUMMARY

The U. S. Environmental Protection Agency (EPA) has sponsored a series of research activities focused on developing organic-acid-enhanced flue gas desulfurization (FGD) technology for existing and new coal burning facilities. In 1982 and 1983, EPA conducted a continuous emissions monitoring program at Springfield City Utilities Southwest Power Plant (SWPP) near Springfield, Missouri, which had installed the first commercial-scale organic-acid-enhanced FGD system. This report presents the results of that investigation.

1.1 BACKGROUND

EPA's Industrial Environmental Research Laboratory at Research Triangle Park (IERL-RTP) has an ongoing research and development program to improve the performance of lime/limestone systems. One of the most promising aspects of that effort has been the use of organic acids as buffering agents to increase soluble alkalinity in limestone FGD systems. Adipic acid was identified as a suitable additive because of physical properties, availability, and cost. After extensive laboratory-, pilot-, and prototype-scale studies on adipic acid-enhanced limestone systems, EPA, in 1981, sponsored a full-scale demonstration at SWPP with Radian Corporation employed as the test contractor.(1)

A total of nine months of testing was conducted at SWPP. Four months were spent at the beginning of the program investigating adipic acid addition in a forced oxidation system. Better than 90 percent SO_2 removal was achieved in a 49-day duration run which was the longest continuous operating period at SWPP to that date. Next, adipic acid addition achieved 85 to 95 percent SO_2 removal in a natural oxidation system over a period of three and one-half months.

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Finally, a mixture of organic dibasic acids (DBA) was tested over a six-week period following the adipic acid testing. DBA, a by-product of adipic acid manufacturing, contains adipic, glutaric, and succinic acids, and is less expensive than adipic acid. Testing at SWPP showed DBA to be very effective in enhancing FGD system performance, resulting in a significant decrease in SO_2 emissions.

A cost analysis was then performed to determine the most cost effective option which would enable SWPP to comply with the 1971 SO_2 emissions standard.[1] Options considered included increasing the slurry rate to the scrubbers, converting the scrubbers to spray towers, adipic acid enhancement, and DBA addition. Lower costs associated with the DBA option as well as its demonstrated effectiveness led SWPP to select DBA for long-term use. In doing so, City Utilities' SWPP became the first commercial-scale facility to utilize DBA in an FGD system application. This report documents commercial operation of SWPP's DBA system covering the period from January 1982 to December 1983.

1.2 PROGRAM OBJECTIVES

Since operation at SWPP represents the first commercial scale use of an organic acid-enhanced FGD sytem, IERL-RTP personnel decided it would be useful to the industry to document system performance following the demonstration program. Consequently, in May 1982, Radian Corporation was contracted to monitor SO_2 emissions and the overall process conditions at SWPP. The primary objectives of this program were to evaluate the performance of the DBA-enhanced system and to note any long-term effects on the process. A secondary objective was to document the performance of the continuous emissions monitoring equipment in 1982 to determine the ability of that equipment to collect data as required in the 1979 revisions to the utility NSPS. A brief description of the SWPP system and a summary of the monitoring program results are presented in the following sections.

1.3 FGD SYSTEM DESCRIPTION

The SWPP FGD system consists of two parallel tray tower modules, each sized to handle 60 percent of the design flow. The coal typically contains from 3.5 to 4.0 percent sulfur, corresponding to inlet flue gas concentrations of 2000 to 2600 ppm SO_2. Limestone preparation, sludge dewatering, and sludge disposal systems are common to the two modules.

Figure 1-1 shows the overall flow scheme for the FGD system. The flue gas enters the presaturator area where it is cooled by clarified liquor (supernatant) from the thickener. The gas then passes through three levels of gas-liquid contact trays, the mist eliminator, and out of the stack. No flue gas reheat is used.

Slurry is circulated from the reaction tank below the scrubber through spray nozzles above the top level of trays. Makeup limestone is added from the limestone storage tank to the reaction tank to maintain the pH setpoint. Solids are first settled in the thickener, and the thickener underflow slurry is dewatered on a vacuum filter belt. The resulting sludge is mixed with fly ash in the pug mill and trucked to an on-site landfill. Supernatant (thickener overflow) from the dewatering operation is returned to the FGD modules as presaturator and mist eliminator wash water. Additional supernatant water is utilized in the limestone preparation area.

A temporary DBA feed system was installed to add DBA solution on a continuous basis. DBA is delivered on site in 6000 gallon (22,710 liter) tank trucks. Hot water (~140°F, 60°C) was circulated through a steam jacket surrounding the tank to inhibit any DBA crystallization.

Initially, DBA was pumped from the tank truck to the ball mill sump. The feed rate was set manually. After the DBA was mixed with the freshly ground limestone slurry from the ball mills, the mixture was pumped to the limestone storage tank. Since the limestone handling equipment was common

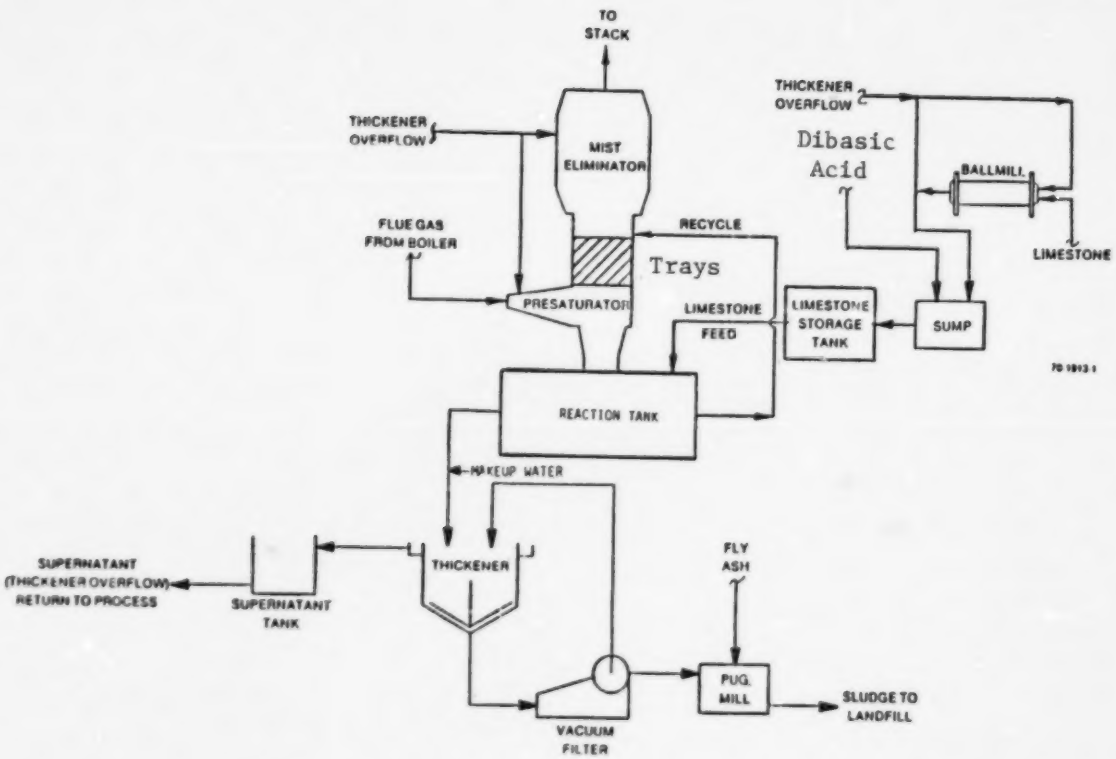

Figure 1-1. SWPP FGD Flow Scheme.

to both scrubber modules, both scrubbers operated at essentially the same DBA concentration. Later in September 1982, the DBA feed system was modified to allow DBA to be fed separately into the reaction tank of either scrubber.

As of May 1983, SWPP began operation with a permanent DBA feed system. This system includes an 18,000 gallon (68,000 liter) stainless steel storage tank, immersion heater, two 30-gpm (114 liters/min) DBA circulation pumps, feed line to the individual modules, and a source of heated flush water. SWPP estimates the cost of the permanent system at approximately $300,000. To date, SWPP has reported no problems with the permanent feed system.

1.4 PROGRAM RESULTS

Analysis of the SWPP FGD system operation in 1982 and 1983 shows that the DBA-enhanced system is continuing to perform well. SO_2 emissions averaged less than 1.0 lb SO_2/MM Btu (430 ng/J) in 1982 and 1983 compared to approximately 5 lb SO_2/MM Btu (2170 ng/J) in 1980 (before DBA use). FGD system reliability averaged nearly 98 percent in 1982 and almost 99 percent in 1983. In 1980, before the adipic acid demonstation program, the FGD system reliability was only 45 percent.

The flexibility of the DBA-enhanced system was well demonstrated in 1982 as SWPP personnel adjusted conditions to minimize scaling in the mist eliminators prior to installation of limestone classifiers. The pH setpoint was reduced from the 5.4 pH setpoint used during the DBA demonstration to 5.0. The reduced pH resulted in increased limestone utilization which helped maintain mist eliminator reliability. Higher DBA concentrations were required with the lower pH setting, which resulted in a higher DBA consumption rate (30 lbs DBA/ton SO_2 (15 g/kg SO_2) removed compared to 15 lbs/ton (25 g/kg) in the demonstration program.) However, the system reliability was maintained at a very high level in spite of a poor limestone grind. The installation of limestone classifiers in late 1982 permits operation at higher pH's with good limestone utilization. 1983 results reported by SWPP show the DBA consumption was reduced to about 25 lbs per ton SO_2 (5 g/kg SO_2)

using the new classifier system. Further reduction in DBA consumption may be possible.

Finally, the continuous emissions monitoring system performed very well. Although called upon to operate nearly all of 1982 (except for boiler outages in April and December), the system average reliability was 97 percent. Only minor problems were experienced, most of which involved power interruptions to the DART® microprocessor. During 1983, very few problems were noted with the CEM system.

1.5 CONCLUSIONS

SWPP's FGD system continues to perform very well with respect to both reliability and SO_2 reductions. DBA has increased the versatility of the FGD system as shown by the successful operation at pH 5.0. SO_2 emissions were well within the 1.2 lb SO_2/MM Btu (520 ng/J) limit, and the reliability of both the FGD system and continuous monitoring system throughout 1982 and 1983 were excellent. In summary, the following conclusions can be drawn from this program:

- Use of DBA allows SWPP to remain in compliance with the SO_2 regulation. An average SO_2 emission of less than 1.0 lb SO_2/MM Btu (430 ng/J) was measured in 1982 and 1983 with DBA addition compared to an emission rate of 5 lb SO_2/MM Btu (2170 ng/J) in 1980 prior to the adipic acid demonstration program.

- DBA greatly increases the flexibility of the FGD system, allowing successful operation over a wide pH range. Operation at a reduced pH in conjunction with better utilization of fresh water to the FGD system allowed SWPP to achieve an overall reliability of 97.9 percent in 1982. An FGD system reliability of 98.7 percent was achieved in 1983.

- Limestone classification and grinding circuit performance is important to overall system performance. In 1982, DBA consumption at SWPP was about 30 lbs/ton SO_2 (15 g/kg SO_2)

due primarily to operation at a lower pH and a decrese in recycle pump performance. A limestone classification system was installed in late 1982, enabling the system to operate at a pH of 5.6-5.8 with good limestone utilization. Higher pH operation reduced the DBA consumption rate to approximately 25 lb/ton SO_2 (5 g/kg SO_2) during 1983. Further reductions in DBA consumption may be possible.

- Finally, continuous monitoring systems can be reliable in commercial operation. The continuous monitoring system at SWPP proved to be 97 percent reliable during 1982. The relative accuracy remained well within tolerance limits set by EPA. Based upon these results, the continuous monitoring system can reliably and accurately supply the data necessary to compute 30-day rolling average emission rates over a long duration.

SECTION 2

INTRODUCTION

The U. S. Environmental Protection Agency (EPA) has sponsored research efforts to develop organic-acid-enhanced flue gas desulfurization (FGD) technology for coal-fired utilities. A demonstration program sponsored by EPA in 1981 at Springfield City Utilities Southwest Power Plant (SWPP) near Springfield, Missouri, showed dibasic acid (DBA), a mixture of organic acids, to be very effective in enhancing FGD performance.[1] After the conclusion of this program, SWPP made a decision to use DBA on a permanent basis. Thus, SWPP became the first commercial-scale facility to use an organic acid additive to enhance SO_2 removal. This report presents the results of an EPA sponsored monitoring program at SWPP to document the first two years of commercial operation.

2.1 BACKGROUND

The majority of FGD systems currently operated by the electric utility industry use lime or limestone as the slurry reagent. Lime/limestone FGD systems are anticipated to be the most widely used technologies in the future because of lower capital and operating costs compared to other FGD technologies. Limestone systems are generally the more cost-effective of the two because of the lower cost of limestone. Limestone systems, however, are limited by the reduced reactivity of the reagent which produces lower soluble alkalinity in the scrubber slurry. This limitation is overcome by operating at higher liquor-to-gas (L/G) ratios and employing larger reaction tanks than other FGD processes.

EPA's Industrial Environmental Research Laboratory at Research Triangle Park, North Carolina (IERL-RTP) has an ongoing research and development program to improve the performance of lime/limestone systems. One of the

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most promising aspects of that effort has been the use of organic acids as buffering agents to increase soluble alkalinity in limestone FGD systems. Adipic acid was identified as a suitable additive because of physical properties, availability, and cost. After extensive laboratory-, pilot-, and prototype-scale studies on adipic acid-enhanced limestone systems, EPA, in 1981, sponsored a full-scale demonstration at SWPP with Radian Corporation employed as the test contractor.

A total of nine months of testing was conducted at SWPP. About four months were spent at the beginning of the program investigating adipic acid addition in a forced oxidation system. After an initial shakedown period, greater than 90 percent SO_2 removal was achieved during a 49 day continuous run. Next, adipic acid addition to a naturally oxidized system achieved 85 to 95 percent SO_2 removal over a period of approximately three and one-half months. Finally, during a six week period, DBA (dibasic acid) was demonstrated as a cost-effective alternative to pure adipic acid in a naturally oxidized process. DBA, a by-product of adipic acid manufacturing, is primarily a mixture of glutaric, adipic and succinic acids.

The results of the DBA test phase of the demonstration program indicated that DBA addition enhances FGD system performance and increases system flexibility. Following the demonstration program, SWPP selected DBA for long-term use as the most cost-effective option to insure compliance with the 1971 SO_2 emission standard. Thus, SWPP became the first commercial-scale facility to use an organic acid additive to enhance FGD system performance. Since SWPP was the first commercial DBA system, IERL-RTP decided to continue to monitor system performance for a period of two years.

2.2 PROGRAM OBJECTIVES

The primary objectives of this program were to: 1) document the first year of commercial operation of the DBA-enhanced system, and 2) demonstrate that DBA would continue to effectively enhance performance over a long duration with the utility in sole control of process operating conditions. Most

of the effort was directed at the continuous monitoring results as a measure of system performance with some effort devoted to analyzing changes in process chemistry.

A secondary objective of the program was to assess the reliability of the continuous emissions monitoring system. The 1979 NSPS for utility boilers places rigorous demands on data acquisition systems. Therefore, EPA was interested in measuring the reliability of the continuous emissions monitoring system at SWPP during 1982.

SECTION 3

FGD SYSTEM DESCRIPTION

The FGD system consists of two parallel tray tower modules, each sized to handle 60 percent of the design flow. The coal typically contains from 3.5 to 4.0 percent sulfur, corresponding to inlet flue gas concentrations of 2000 to 2600 ppm SO_2. A monthly summary of SWPP coal analyses are presented in Tables 3-1 and 3-2.

Figure 3-1 shows the overall flow scheme for the FGD system. The flue gas enters the presaturator area where it is cooled by clarified liquor (supernatant) from the thickener. The gas then passes through three levels of trays where SO_2 removal is accomplished, through the mist eliminator, and out the stack. No flue gas reheat is used.

Slurry is circulated from the reaction tank below the scrubber through spray nozzles above the top level of trays. Makeup limestone is added from the limestone storage tank to the reaction tank to maintain the pH setpoint. The solids content of the recirculating slurry is controlled by pumping slurry to the thickener. Solids are first settled in the thickener, and the thickener underflow slurry is dewatered on a vacuum filter belt. The resulting sludge is mixed with fly ash in the pug mill and trucked to an on-site landfill. Supernatant (thickener overflow) from the dewatering operation is returned to the FGD modules as presaturator and mist eliminator wash water. Additional supernatant water is utilized in the limestone preparation area.

3.1 LIMESTONE PREPARATION FACILITY

The limestone used in the FGD system is obtained from several quarries around Springfield and trucked to SWPP, where it is stored in "ready" piles. Limestone is conveyed from the storage piles to one of two 1500 cubic feet

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TABLE 3-1. SWPP AVERAGE MONTHLY COAL ANALYSES FOR 1982*

Month	% by Weight (as received)					Heating Value (Btu/lb)
	Moisture	Ash	Volatiles	Fixed Carbon	Sulfur	
January	9.8	13.5	35.5	41.1	3.9	11,440
February	9.8	13.2	35.1	41.9	3.7	11,670
March	7.8	12.8	35.5	44.0	4.3	11,830
April	UNIT OUTAGE					
May	7.1	12.9	33.2	46.9	2.9	12,000
June	8.3	12.0	35.4	44.2	3.1	11,970
July	7.2	12.4	37.0	43.5	3.7	11,940
August	8.1	13.8	37.4	40.7	3.1	11,550
September	6.1	13.6	39.6	40.7	3.8	11,780
October	5.2	10.5	38.4	46.0	3.7	12,500
November	6.6	10.1	38.7	44.7	3.7	12,540
December	UNIT OUTAGE					

*Weekly coal analyses used to calculate monthly averages are presented in Appendix A.

TABLE 3-2 SWPP AVERAGE MONTHLY COAL ANALYSIS FOR 1983

Month	% by Weight (as received)					Heating Value (Btu/lb)
	Moisture	Ash	Volatiles	Fixed Carbon	Sulfur	
May*	9.4	9.8	36.5	44.2	3.6	11,923
June	8.9	12.2	36.7	42.2	3.8	11,895
July	8.9	12.4	36.6	42.1	3.9	11,864
August	6.7	10.9	37.2	45.2	3.8	12,444
September	7.0	11.7	36.7	44.6	3.9	12,212
October	10.4	12.0	37.2	40.3	3.9	10,915
November	8.0	12.1	36.6	43.3	3.9	11,979
December	8.0	12.1	36.3	43.3	3.9	11,979

*Unit outage from December 1982 through May 1983

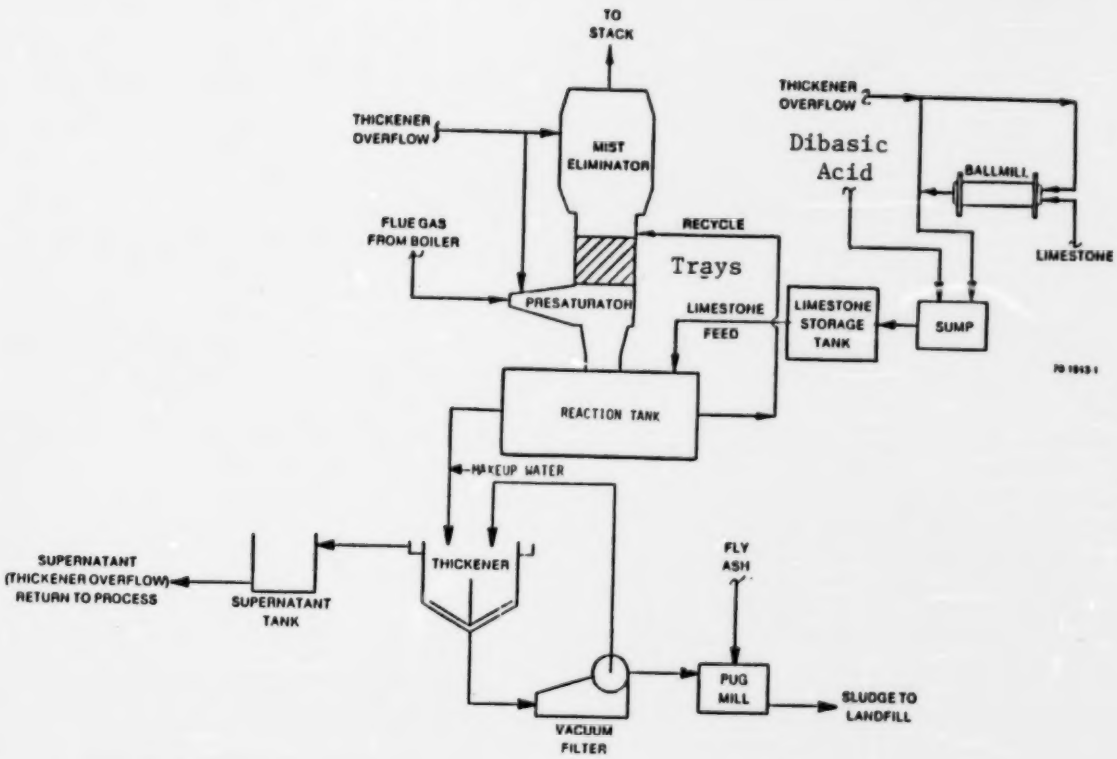

Figure 3-1. SWPP FGD flow scheme.

(45 m^3) storage silos prior to being fed to the wet ball mills. Each ball mill is designed to process 9 tons (8160 kg) of limestone per hour. The resulting slurry is 65 percent solids by weight and 50 to 60 percent through 200 mesh. Limestone classifiers have been installed recently to further reduce the size of the feed solids. The slurry from each ball mill is discharged into a 1700 gallon (6440 liter) slurry sump. Here, the 65 percent limestone slurry is diluted to a 30 percent solid slurry and pumped to the limestone storage tank. The limestone is supplied to the scrubbers through a recycle-type piping arrangement which allows higher slurry velocities and reduces chances of plugging. Limestone transfer pumps (1 operating/1 standby per scrubber module) feed the limestone slurry to each of the scrubber modules based on an automatic pH control system. Control valves at each of the modules control the amount of limestone makeup fed to the reaction tanks to maintain the pH setpoint. The remainder of the limestone slurry is recycled back to the limestone storage tank.

3.2 SCRUBBER MODULES

The flue gas stream is divided downstream of the electrostatic precipitator and passed through one of two scrubber modules. Supernatant from the thickener cools the gas entering the presaturation sections of the scrubber modules from 300 to 120°F (149 to 52°C). The gas then passes through three slurry-contacting stages. Each stage originally consisted of ten 6 ft. x 6.5 ft. x 3 ft. cages (1.8 x 1.95 x 0.9 m) which contained approximately four inches (10.6 cm) of plastic TCA spheres (1.25 inches [3.18 cm] diameter). In May 1981, the TCA cages in one of the modules were removed and three levels of perforated trays were installed. The other module was likewise modified in October 1981. The gas flow rate through each module is approximately 300,000 acfm (9000 m^3/min) saturated at 125°F (52°C) at full load conditions.

The scrubber feed slurry is recycled from the 165,000 gal (627 m^3) concrete reaction tank through a 36 inch (91 cm) pipe at a nominal rate of 13,500 gpm (51.3 m^3/min). At full load conditions, the L/G ratio is 45 to 50

gal/1000 acf (7 to 8 ℓ/Nm^3) and the gas phase pressure drop is 10 to 12 inches H_2O (25 to 30 cm). Eighteen spray nozzles are positioned above the top stage of trays to distribute the slurry. The spent slurry and excess supernatant from the presaturator section drain to the reaction tank. A constant level is maintained in the reaction tanks by gravity overflow to a common sump tank between the two reaction tanks. Slurry is then pumped from the sump to the thickener to control the reaction tank slurry solid concentration at about 10 weight percent.

Before the gas stream leaves the scrubber, it passes through two levels of fiberglass chevron mist eliminators to remove entrained slurry. The lower mist eliminator is continuously rinsed with supernatant water (top and bottom) to prevent solids buildup. Spent wash water is collected in trap-out trays below the lower chevrons and drains into the sump between the reaction tanks. The upper mist eliminator is not washed.

The scrubbers are constructed of carbon steel and lined with natural rubber. Reaction tanks are concrete. Duct work connecting both modules to the stack is 1/4 inch (0.64 cm) thick carbon steel lined with fiberglass reinforced polyester.

3.3 SOLIDS DEWATERING

Thickener underflow slurry containing 25 to 40 weight percent solids is pumped from below the center of the 860,000 gal (3.260 m^3) thickener to the vacuum filter belt. The flow rate is controlled by monitoring the torque on the thickener rake. If the torque drops below a preset value, low solids content in the thickener underflow is indicated. The underflow stream is then recycled to the thickener mix well to build thickener solids inventory while maintaining slurry velocities through the underflow piping, which minimizes chances for plugging.

Once the underflow slurry reaches the filter belt, excess water is removed from the sludge through the cloth belt by a 15 inch (38.1 cm) H_2O vacuum produced by 300 HP (224 kilowatt) pump. The filtrate is collected in tanks below the belt and then pumped back to the thickener. Overflow from the thickener drains to the supernatant tank where it is pumped to the scrubber modules and used to maintain tank levels, for quench purposes, for limestone grinding, etc.

The cake produced from the filtering process contains between 50 and 70 weight percent solids. Filter cake solids content is dependent upon the oxidation of the sulfite in the reaction tank and the crystal morphology of the solids. As a final step in the disposal process, the filter cake is mixed with fly ash in a pug mill and trucked to the landfill.

In emergency conditions, such as during filter equipment malfunctions, the thickener underflow slurry can be pumped to either the ash pond or the emergency pond to keep the FGD system in operation without overfilling the thickener with solids. In this situation, additional makeup water and DBA are required by the FGD system to replace that lost with the underflow slurry. If the emergency pond is used, then clear liquor laden with DBA can be returned to the FGD system to recover some of the DBA which was lost.

3.4 DIBASIC FEED SYSTEM

DBA is a mixture of glutaric, succinic, adipic and nitric acids and other organic nitrogen compounds. It is obtained as a by-product in the production of adipic acid. SWPP used a 20 percent DBA solution supplied by Monsanto Corporation during most of 1982. In mid-August, however, SWPP changed to a 50 percent solution supplied by DuPont, which they used for the remainder of the year. Typical composition (dry basis) for both the Monsanto and DuPont products are shown in Tables 3-3 and 3-4, respectively.

TABLE 3-3. TYPICAL COMPOSITION OF MONSANTO AGS DIBASIC ACID (DRY BASIS)*

Component	Weight Percent
Glutaric Acid	56
Succinic Acid	19
Adipic Acid	14
Nitric Acid	11

*DBA is a by-product and its composition may vary.

Source: Reference 2

Table 3-4. TYPICAL COMPOSITION OF DUPONT DIBASIC ACID (DRY BASIS)*

Component	Weight Percent
Glutaric Acid	56
Succinic Acid	23
Adipic Acid	20
Organic Nitrogen Compounds	1
Nitric Acid	0.2
Copper	0.1
Vanadium	0.008

*DBA is a by-product and its composition may vary.

Source: E. I. DuPont DeNemours and Company, Inc.

A temporary DBA feed system was also used during 1982. The entire temporary system was assembled on-site in a matter of a few days at a cost of approximately $1000[3]. A flow schematic for the temporary feed system is shown in Figure 3-2. As shown, a 6000 gal. stainless steel tanker trailer served as the DBA storage tank. Hot water (140°F) supplied via two residential hot water heaters was recirculated through the thermal jacket of the storage tanker to prevent crystallization of the DBA. Crystallization can

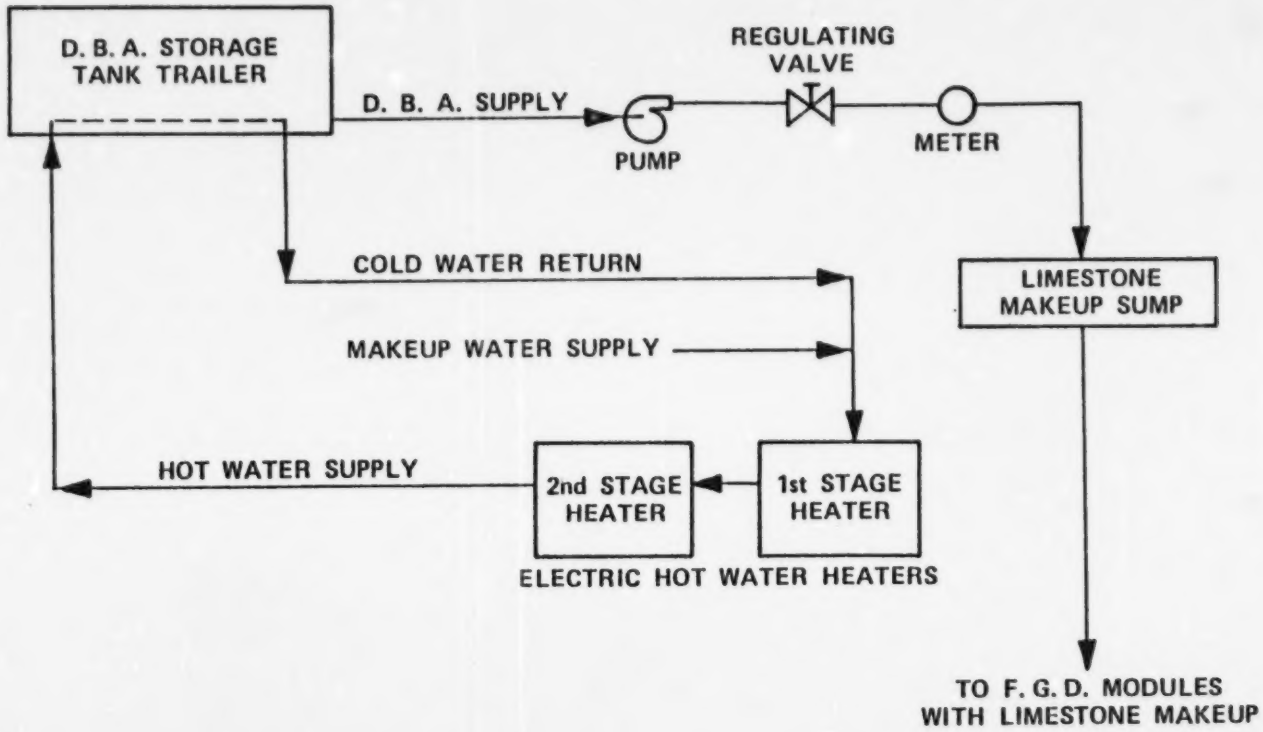

Figure 3-2. DBA Flow Schematic Temporary System.

Source: Reference 4

be a problem if the solution is allowed to cool. For example, a 20 percent DBA solution must be maintained above 75°F to prevent crystallization. As shown in Figure 3-3, higher DBA concentrations will require higher temperatures.

Initially, DBA was added to the limestone sump from the tanker. After mixing with the freshly ground limestone from the ball mills, the mixture was pumped to the limestone storage tank. Since the limestone handling system is common to both scrubber modules, both scrubbers operated at essentially the same DBA concentration. Late in September, however, the DBA system was upgraded to allow DBA to be fed directly to the individual scrubber reaction tanks. This modification allowed the system to be more responsive to sudden process changes such as unit load swings.

Minor problems were encountered with the temporary system due to DBA crystallization and subsequent feed system pluggage. For the most part, these incidents were restricted to times when a new shipment of DBA had cooled in transit and was being transferred to the storage tanker. The size of the storage tanker (approximately the same size as the transport vessel) also necessitated careful scheduling of DBA shipments. Overall, however, operation of the temporary system proved to be very effective in 1982, with SWPP achieving an overall SO_2 removal efficiency of 84.3 percent for the year, which included bypass, startup and shutdown periods (4).

A permanent DBA feed system (see Figure 3-4) is now operational at SWPP. The permanent system, estimated to cost approximately $300,000, includes an 18,000 gallon stainless steel storage tank equipped with an immersion heater, two 30 gpm DBA circulation pumps, feed lines to the individual scrubbers, and a source of heated flush water. Deliveries of DBA are transferred to the storage tank via a closed pneumatic transfer system to avoid exposure to reduced ambient temperatures. Since becoming operational in May 1983, SWPP has reported no problems with the permanent system.[3,4] SWPP achieved an average SO_2 removal efficiency of 85.1 percent during 1983 including startup, shutdown, and upset conditions.

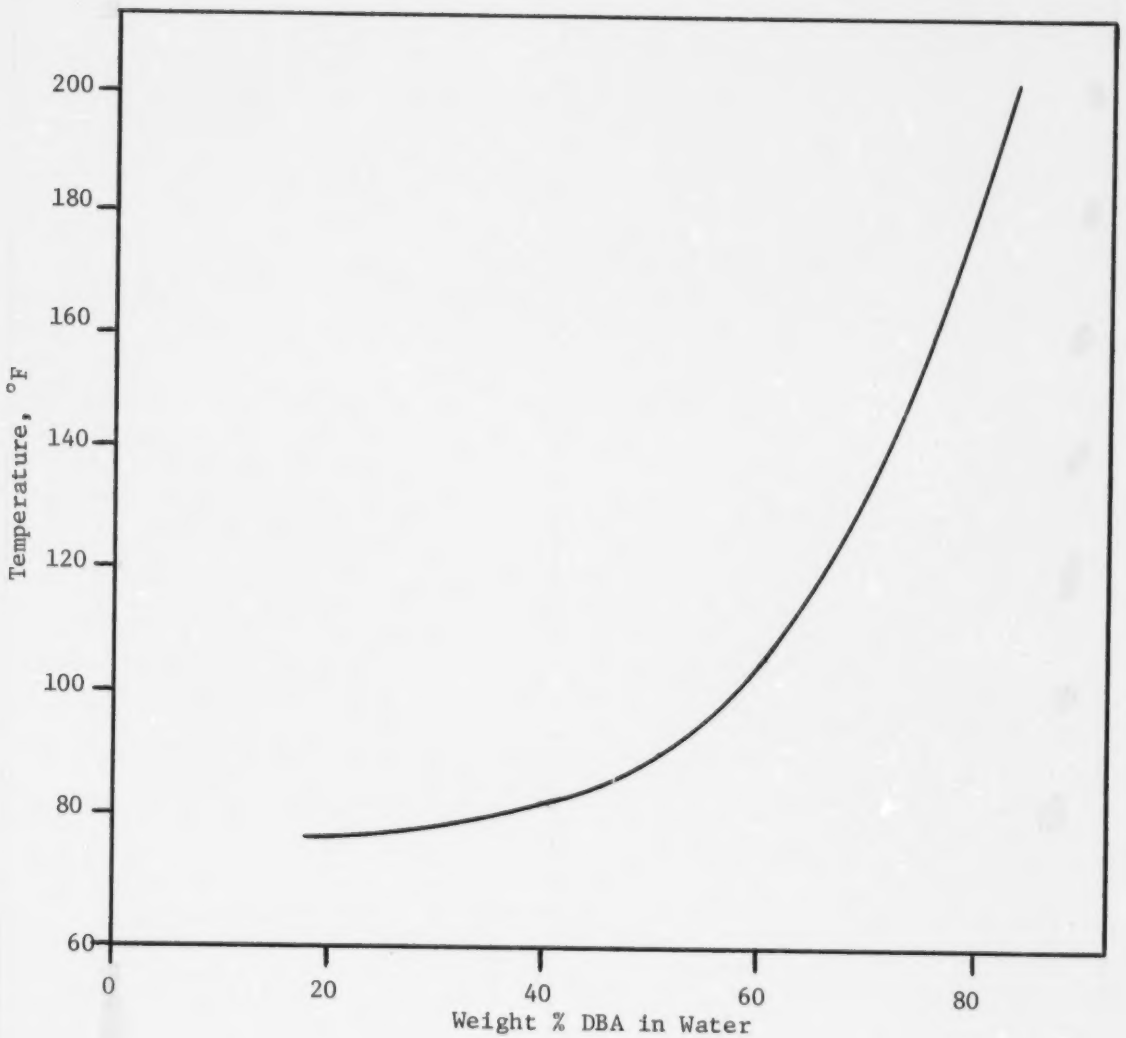

Figure 3-3. Solubility of DBA in Water.

Source: E. I. DuPont De Nemours and Company, Inc.

(Petrochemical Department Intermediate Division publication E - 55901 Rev. 3/83)

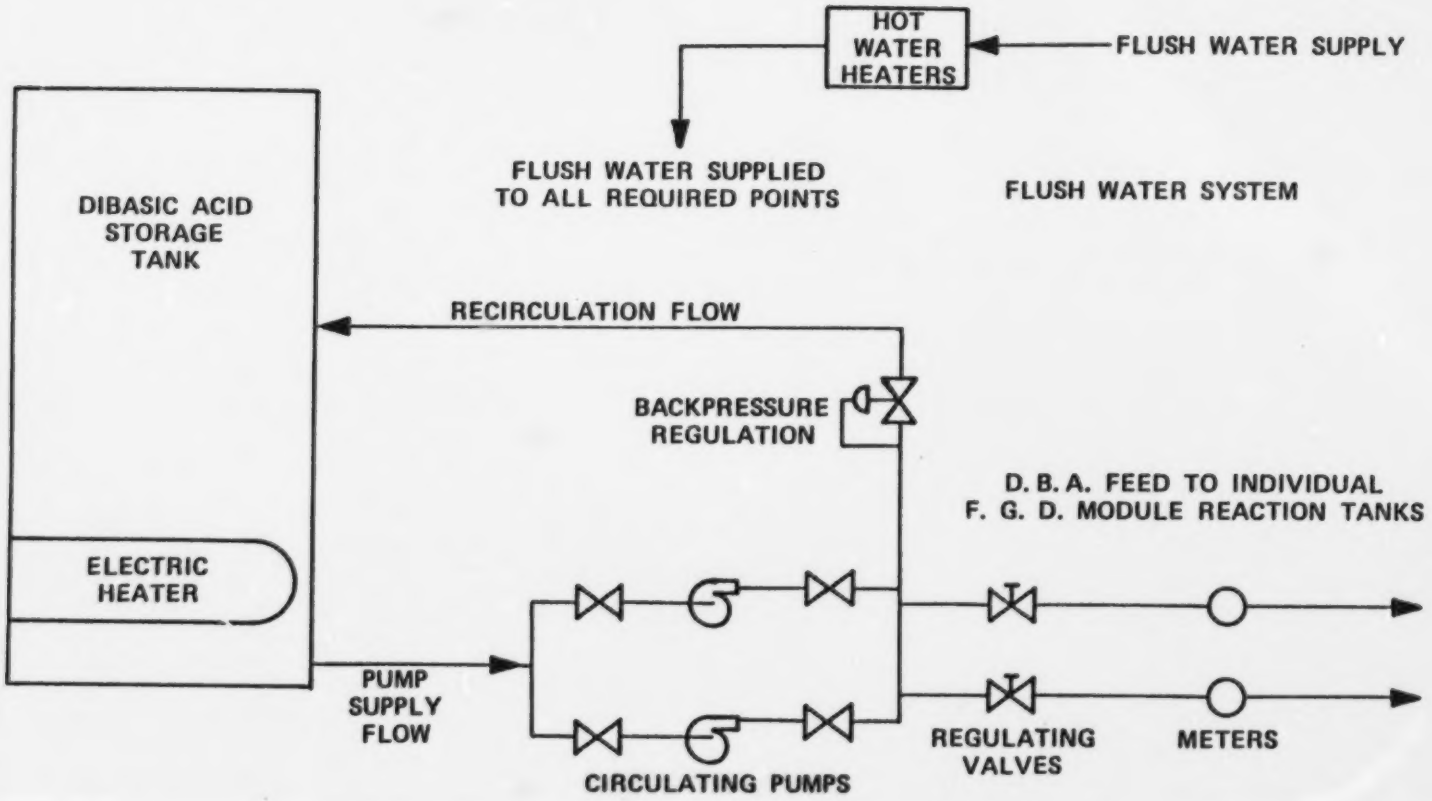

Figure 3-4. DBA Flow Schematic Permanent System.

Source: Reference 4

SECTION 4
ANALYSIS OF PROCESS CONDITIONS

One of the objectives of the program was to identify any long-term effects of DBA addition to a lime/limestone FGD system. Along with the SO_2 emissions data, SWPP personnel supplied copies of the scrubber operator's log sheets, the plant chemist's DBA concentration log sheet, and the results of the weekly proximate coal analyses during 1982. In 1983, data was obtained from City Utilities quarterly report submitted to the EPA. This section summarizes the results of the analysis of that data.

4.1 BACKGROUND

Data from January to June 1982 were obtained from SWPP records. In June, Radian personnel upgraded the data acquisition system and arranged for all data to be recorded on computer diskettes using the DART® microprocessor. The diskettes were sent to Radian by SWPP personnel on a regular basis, where they were analyzed and stored on tape using an IBM 3033 computer. An analysis of this data as well as the data supplied by SWPP prior to June is presented in the following sections. In 1983, the data was obtained from daily emission summaries which were submitted to the Region VII enforcement division of the EPA.

4.2 SCRUBBER PERFORMANCE

An inlet SO_2 monitor was used during the demonstration program to measure the scrubber inlet SO_2 concentrations. This monitor was provided only for the duration of the demonstration program and was not available during the 1982 SWPP monitoring program. Therefore, the SO_2 concentration in the scrubber inlet flue gas was estimated from weekly SWPP proximate coal analyses (see Appendix A). Inlet concentrations between analyses were estimated by linear extrapolation.

SO_2 emission rates for each scrubber module were calculated based upon continuous monitor data. SO_2 removals were estimated using the continuous monitor results and an estimate of the inlet SO_2 concentration from the proximate coal analyses as described above. A summary of the SO_2 removal data for both modules during 1982 is provided in Appendix B. Overall SO_2 emissions data for 1983 are included in Appendix D. Only overall emissions are reported in Appendix D; no individual module data were obtained.

Perhaps the best indication of the performance of the SWPP scrubbers is reflected in the 1982 and 1983 average monthly emission rates plotted in Figure 4-1. For comparison, 1980 emission rates (prior to DBA use) are also shown. As shown, DBA has allowed SWPP to reduce emissions from an average of about 5 lb SO_2/MM Btu in 1980 to less than 1.0 lb SO_2/MM Btu in 1982 and 1983. Over the same periods, overall SO_2 removal has likewise increased from an average of 26 percent in 1980 to 84 percent in 1982 and 85 percent in 1983. SWPP has also remained in compliance, even during periods when the coal sulfur level increased to 4.7 percent (normal is 3.5 to 4.0 percent S). The emission rate increased at the end of 1982 because of installation of classifiers in each limestone circuit. The module under service was by-passed in order to maintain generation under terms of the consent decree.

In addition, during most of 1982, the scrubbers were operated at a pH of 5.0 to increase limestone utilization and reduce mist eliminator pluggage. This is significantly less than the 5.4 pH at which the absorbers were operated during the 1981 DBA demonstration testing. Despite the low pH operation, DBA allowed SWPP to remain in compliance throughout the year. Thus, SWPP utilized the versatility provided by DBA to avoid a potentially severe and costly maintenance problem.

Finally, the daily average SO_2 emission exceeded 1.2 lb SO_2/MM Btu only four times when the scrubber modules were in operation for 18 or more hours per day (three times on Module S-1 and once for Module S-2. Two of these times, the other scrubber's SO_2 emission was sufficiently low such that the

overall emission rate (average of S-1 and S-2 emissions) was less than 1.2 lb SO_2/MM Btu. In the other two cases, only one scrubber was in use due to low boiler loads. There is also some evidence indicating that sulfite blinding of the limestone may have been a problem during these two periods. Sulfite blinding is thought to involve the precipitation of calcium sulfite on the surface of limestone particles. Decreases in pH and/or sluggish pH control with an associated drop in SO_2 removal characterize this phenomena.

The FGD system continued to perform well during 1983. As in 1982, the average SO_2 emission rate was less than 1.0 lb SO_2/MM Btu. The 24-hour average emission rate exceeded 1.2 lbs SO_2/MM Btu seven times in the 135 days of reporting. All but one of the seven days had high values because of boiler startups without the scrubbers on-line. Most of the outages were due to leaking condensor tubes and boiler water wall tube leaks. The system still averaged above 85 percent SO_2 removal for the year in spite of several incidences of start up and shutdown experienced during the last quarter. (An outage encompassing the first 4 months of 1983 was required for system maintenance including relining the stack.)

4.3 DBA CONSUMPTION

Throughout the program, SWPP supplied Radian with copies of log sheets taken at SWPP so that process conditions at the plant could be tracked. One parameter of particular interest was the consumption of DBA. At the end of the demonstration program (September and October 1981), approximately one and a half months of testing were conducted to evaluate the performance of DBA.[1] At that time it was determined that a DBA feed rate of about 60 lb/hr (27 kg/hr) was required to attain 85 percent SO_2 removal efficiency at a pH of 5.4. That translates to a buffer capacity of about 500 ppm (adipic acid equivalent) and a consumption rate of approximately 15 lb DBA/ton SO_2 (7.5 DBA/kg SO_2) absorbed.

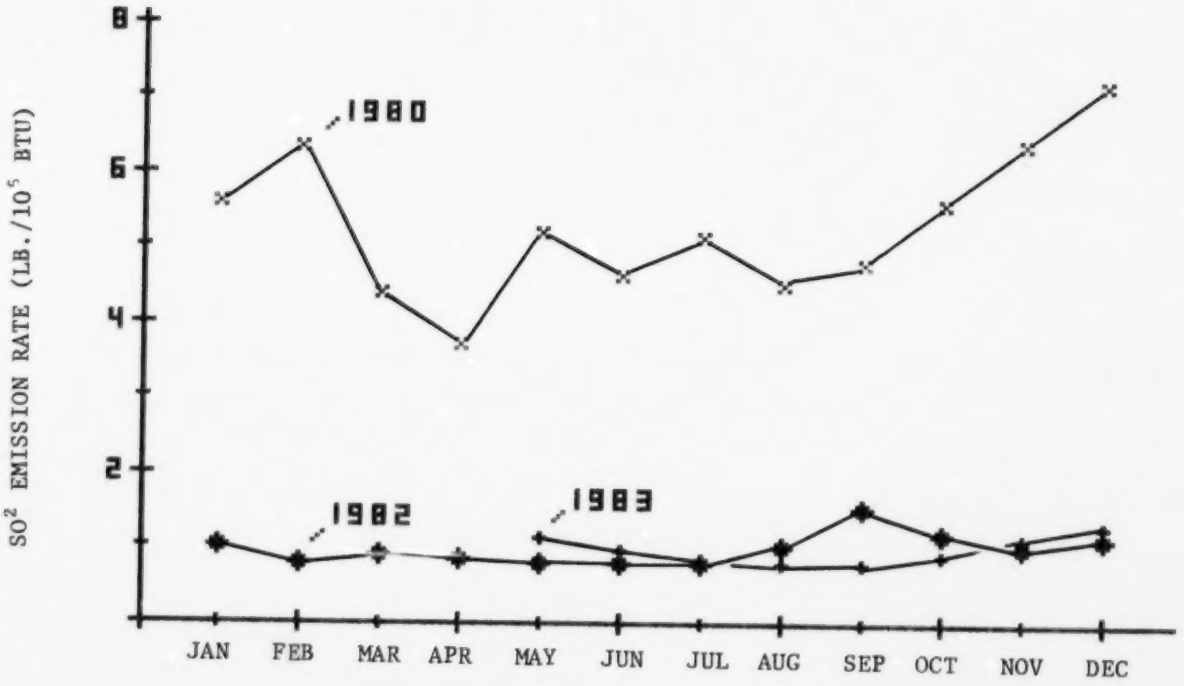

Figure 4-1. Comparison of SWPP Monthly Average SO_2 Emission Rates, 1980 vs. 1982 and 1983.

Source: Reference 4

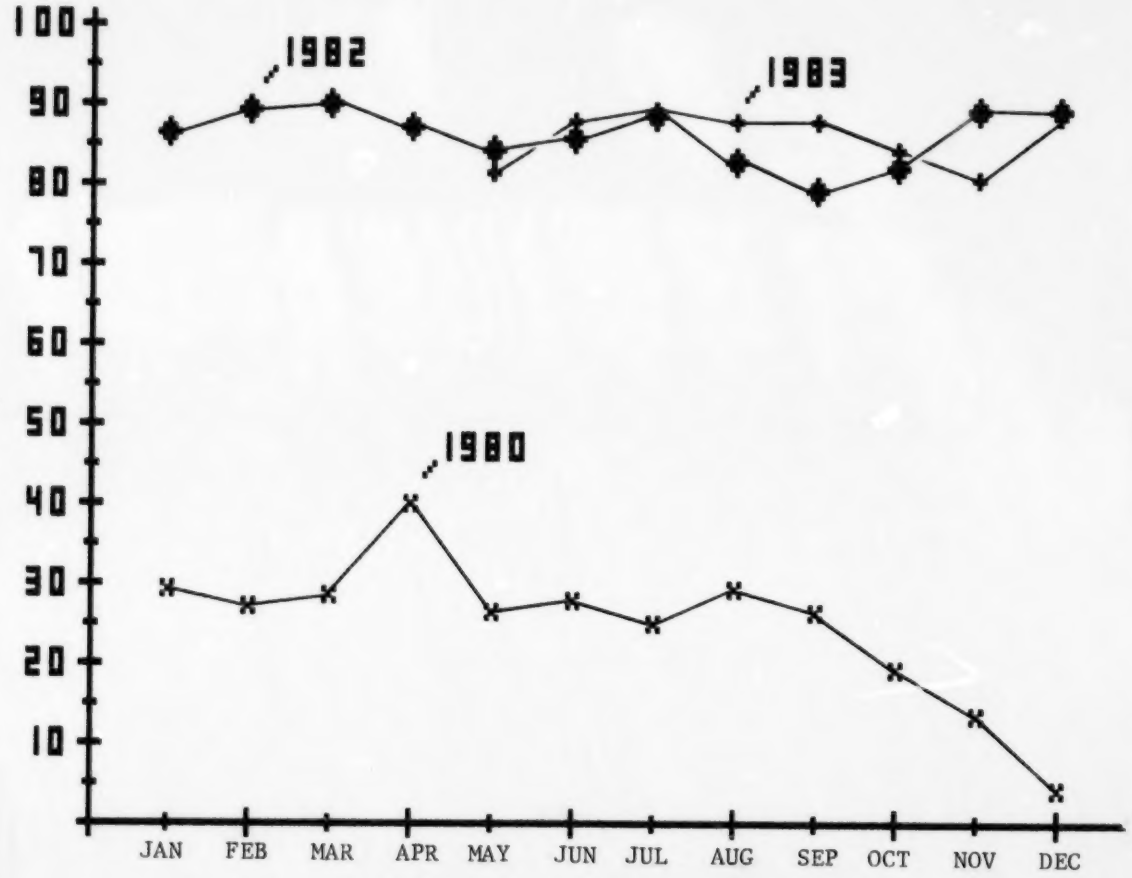

Figure 4-2. Comparison of SO_2 Removal Efficiencies: 1980 vs 1982 and 1983.

Source: Reference 4

The data for calculating the DBA consumption for 1982 are presented in Table 4-1. The average inlet SO_2 concentration for each period was calculated from the coal analyses performed by SWPP personnel (see Appendix A). The I.D. fan amps for each module were averaged (see Appendix B) and converted to a flue gas flow rate in dry standard cubic feet per minute. Then, an average SO_2 absorption rate in lbs SO_2 absorbed per minute could be calculated. Finally, the total tons of SO_2 absorbed for the period was determined.

As shown in Table 4-1, the DBA consumption rate at SWPP during the current program was nearly twice that measured during the demonstration program. Also, the average buffer capacity, expressed as equivalent adipic acid parts per million, was about twice as high. Two reasons have been identified as contributing to the increased DBA consumption rates. The first is a decrease in the slurry recycle pH setpoint. Second, SWPP seems to have experienced a reduction in the slurry recycle flow rate. Both of these conditions will cause the required DBA concentration and consumption rate to increase.

The major difference in operating philosophy between the DBA test phase in the demonstration program and 1982 operation was related to the recycle slurry pH setpoint. During the demonstration program, the pH was controlled at 5.4. However, SWPP reduced this pH to 5.0 during 1982 to improve limestone utilization in an attempt to improve mist eliminator reliability. (Mist eliminator reliability has been greatly improved by this technique and by revising the system water balance and washing with greater amounts of fresh water.) While the lower pH does improve limestone utilization, a higher concentration of DBA is required to achieve the desired SO_2 removal. Since the system is operating at a higher concentration, the DBA lost in the water associated with the waste sludge will also increase. Furthermore, degradation of DBA will increase at lower pH operation. Thus, DBA use would be expected to increase significantly as reflected in the DBA consumption data.

During the October 28 through December 1, 1982 period, the water balance had been changed and operating conditions were returned to more closely match

TABLE 4-1. SUMMARY OF 1982 DBA CONSUMPTION RATES AT SWPP

Period	Lbs DBA Used	S-1 Hours Operated	S-1 Average SO_2 Removed (lbs SO_2/min)	S-2 Hours Operated	S-2 Average SO_2 Removed (lbs SO_2/min)	Total Tons SO_2 Removed	lbs DBA Consumed / Ton SO_2 Removed
Jan 1-Feb 4	57,665	752.4	67.9	673.5	60.9	2,763	20.9
Feb 5-March 4	38,043	283.3	73.2	443.0	72.0	1,579	24.1
March 5-March 22	40,618	397.4	69.2	0	0	825	49.2
May 10-June 15	48,342	614.6	44.4	332.6	38.9	1,207	40.1
June 16-July 2	17,022	103.0	59.8	311.8	53.5	685	24.8
July 3-July 30	40,310	443.8	63.7	528.9	55.2	1,724	23.4
July 31-Aug 28	64,689	565.4	52.9	540.3	45.9	1,641	39.4
Aug 29-Oct 1	64,190	596.3	65.0	633.5	58.7	2,278	28.2
Oct 2-Oct 27	62,391	533.6	59.5	547.8	51.3	1,796	34.7
Oct 28-Dec 1	65,860	772.6	58.1	755.4	53.1	2,550	25.8
TOTAL -	499,130	5062.4		4766.8		17,048	29.3

those observed in the demonstration program. In November, the average recycle stream pH was 5.35, the SO_2 removal efficiency averaged 87.5 percent, and the average load was 141 Mw. These conditions are very similar to the DBA portion of the demonstration program. However, the required DBA concentration was 880 ppm with an associated DBA consumption rate of 25.8 pounds of DBA per ton of SO_2 (13 g DBA/kg SO_2) removed (versus 15 lb DBA/ton SO_2 [7.5 g DBA/kg SO_2] during the demonstration program).

In examining reasons for the increased consumption, there does appear to have been a drop-off in recycle pump performance between the demonstration program and the latter part of 1982. Recycle slurry rates are not routinely measured by SWPP. The electrical current consumption (amperage) for recycle is recorded, though, and should reflect a trend in pump performance. During DBA testing in 1981, the recycle pumps on Module S-1 operated at an average of 52 amps. In November 1982, Module S-1 recycle pumps averaged only 47 amps. Similarly, the Module S-2 pump amps dropped from an average of 50 amps in 1981 to 45 amps in November 1982. Thus, decreased pump performance and therefore a lower slurry flow rate was probably a major contributor to the increased DBA comsumption requirements in the latter part of 1982.

In summary, DBA consumptions were up during 1982, averaging about 30 lbs DBA/ton of SO_2 removed. To a large extent, this was due to a decision by SWPP to operate at a lower pH to achieve better limestone utilization and improve mist eliminator reliability. Certainly this decision increased DBA costs. However, it does serve to illustrate the versatility in operation which DBA has allowed SWPP. Lower pH operation to improve reliability and limestone utilization did not result in non-compliance with the SO_2 emission standard.

In late 1982, SWPP installed a limestone classification system which produces a finer limestone grind. The pH setpoint for the scrubber recycle stream is now about 5.6. In 1983, the DBA usage dropped to approximately

25 lb DBA/ton SO_2 removed while maintaining good limestone utilization and mist eliminator reliability.[5] This indicates that further optimization of DBA addition may be possible since this is still greater than that achieved during the demonstration program.

4.4 EQUIPMENT INSPECTION AND RELIABILITY

An inspection of SWPP's scrubber internals was made in December 1982 by Radian personnel. Very little scale buildup was found anywhere in the system. There was no pluggage of the trays or of the mist eliminators. Mist eliminator pluggage had historically been a problem at SWPP. Since the end of the demonstration program, SWPP has increased the proportion of raw water in the mist eliminator wash water and, as noted earlier, operated at a recycle slurry pH near 5.0 for much of the time. These measures seem to have shown positive results in the reduction of mist eliminator pluggage.

The FGD system reliability was also excellent during 1982 and 1983. As shown in Table 4-2, the SWPP FGD system average reliability for 1982 and 1983 was 97.9 and 98.7 percent, respectively. This compares to an FGD system reliability during 1980 of only 45 percent.[1] DBA is certainly not the sole reason for this improvement. SWPP has made major equipment improvements since 1980. However, the versatility offered by DBA, which allowed SWPP to operate successfully at a lower pH (5.0) in 1982 to reduce mist eliminator pluggage, was certainly a major factor.

TABLE 4-2. SWPP FGD SYSTEM RELIABILITY IN 1982 and 1983

Month	Reliability[1] 1982	1983
January	98.6	-outage-
February	99.8	-outage-
March	98.5	-outage-
April	- outage -	-outage-
May	96.4	96.1
June	97.8	99.9
July	98.0	99.1
August	96.7	98.5
September	99.9	99.8
October	96.0	99.7
November	97.6	99.6
December[2]	92.8	96.7
Average	97.9	98.7

[1]Reliability = $\frac{\text{Hours FGD system operated}}{\text{Hours called upon to operate}} \times 100$

[2]Scheduled outage started 12/3/82. Down a short time due to lightning.

Source: SWPP Quarterly Status Reports submitted to U.S. EPA Region VII.

SECTION 5

DATA ACQUISITION

5.1 CONTINUOUS EMISSIONS MONITORING SYSTEM

The continuous emissions monitoring system (CEMS) data were used for two purposes in this program. The first was to monitor FGD system performance with DBA addition over an extended duration of operation. The SO_2 emissions limit at SWPP is 1.2 lb/MM Btu, and the results of the CEMS were used as the primary means of evaluating the ability of the DBA-enhanced system to meet the 1.2 lb/MM Btu standard. A second purpose was to demonstrate the ability of the CEMS to gather the type of data required by the 1979 revision to the utility NSPS.[6] To meet EPA requirements for data capture, at least two data points must be taken each hour for a minimum of 18 hours each day and 22 days per 30 day period. The goal of the CEMS is to collect at least 4 data points per hour for 24 hours.

The monitoring system operates by periodic extraction of a sample of flue gas from the plant duct work and analysis of the gas for its SO_2 and O_2 concentrations. At SWPP, the flue gas exiting each scrubber is analyzed using a DuPont Model 460, modified for two point sampling, and a Thermox WDG III analyzer arrangement. Spectrophotmetric measurements were made at 302 nM rather than the standard 280 nM because of difficulties encountered certifying the new monitors. It has not been determined if DBA addition was responsible for this problem.

Figure 5-1 shows the location of the instruments and sample ports with respect to the scrubber. The locations of the sample ports were limited to those installed during construction of the plant. They represent the best locations for determining the individual performance of the two modules.

(Effective process monitoring requires that emissions from each module be measured rather than measuring emissions at the stack as would normally be required for compliance purposes.)

Each of the sample acquisition systems consist of:

- a 30 micron stainless steel mesh filter and shield,
- a 1/2 inch (1.27 cm) stainless steel probe fixed in the center sample port,
- 50 feet of 400°F (204°C) self-limiting, heat traced, insulated, 1/4 inch (0.6 cm), double tube, Teflon sample line, and
- a moisture trap located in the DuPont analyzer.

The filter is positioned in the centroid of the duct at each sample location. This location was selected as being representative during the demonstration program.[1]

To monitor the performance of both modules, the analyzer cycles from one scrubber to the other every six minutes. The outlet for one module is sampled for three minutes of the six minute period. For the other three minutes, regulated instrument air purges the instruments and sample acquisition lines to reduce problems with corrosion and pluggage. The gas samples are kept above the moisture dewpoint by heat tracing to prevent water condensation in the sample acquisition system lines.

The signal outputs from the analyzers are recorded using a Radian DART® microprocessor which generates an hourly SO_2 emission report. At the end of each 3-hour period, a 3-hour average is also calculated and displayed. At the end of every day, a daily report is printed which includes all hourly averages and a 24-hour average.

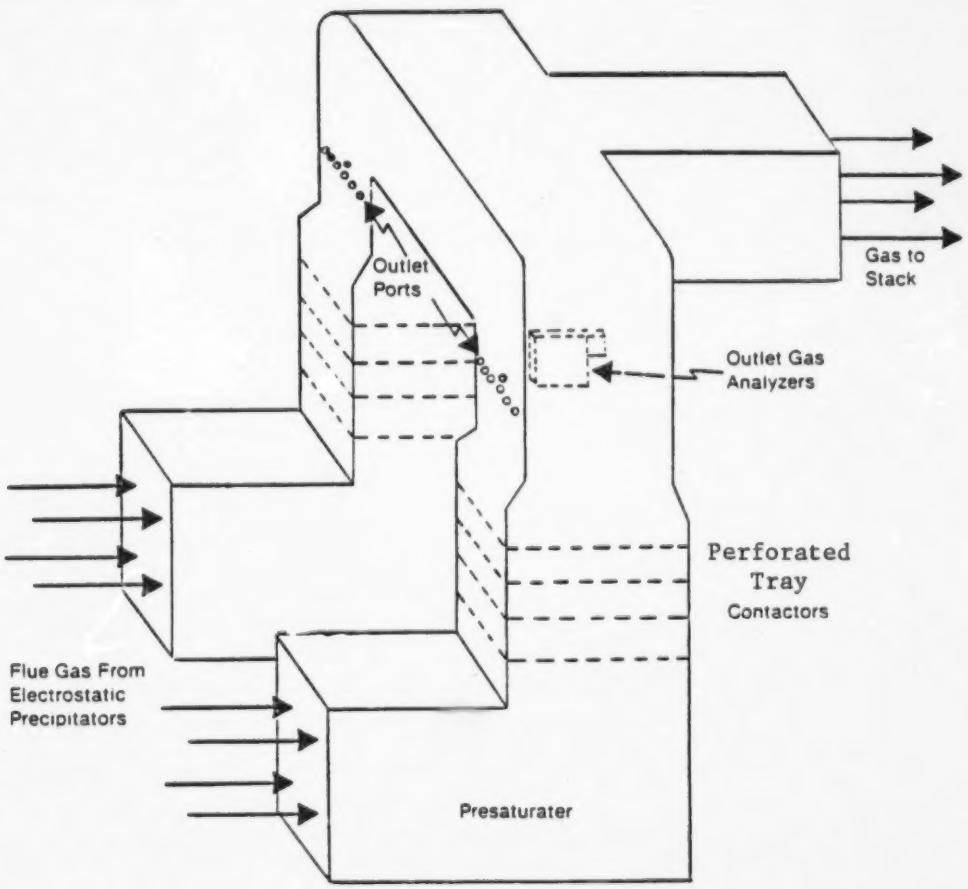

Figure 5-1. Location of Continuous Monitors and Sample Ports at SWPP.

5.2 CEMS RELIABILITY

The continuous emissions monitoring system (CEMS) proved to be very reliable, capturing approximately 97 percent of the available data for each scrubber throughout 1982. Table 5-1 gives the number of hours of operation, the number of hours for which data were collected, and the percentage data capture for each module by month. As expected, the lowest data capture was achieved in January. It was during this period that SWPP personnel were first called upon to maintain and troubleshoot the CEMS system. (During the demonstration program, Radian Corporation engineers performed all system maintenance.) As SWPP personnel gained more experience with the CEMS system, the reliability increased even further. During the remainder of 1982, the CEMS system proved to be 98 percent reliable.

The high reliability of the CEMS system is even more impressive when one considers that the SWPP FGD system was 97.9 percent reliable during 1982. Thus, the CEMS system was called upon to operate essentially all of 1982 with the exception of scheduled outages in April and December. Most of the minor problems encountered were, in fact, caused by power interruptions.

5.3 QUALITY ASSURANCE

In order to verify the accuracy of the CEMS system, a shortened relative accuracy test was performed on August 19, 1982. Six EPA Method 6 tests were run by drawing a sample through the same probe used by the continuous monitors. Table 5-2 shows the results of the abbreviated relative accuracy test. The relative accuracy as defined by EPA was about 18 percent, which is within the 20 percent allowable. Note that the EPA procedure for relative accuracy calls for a minimum of 9 tests, while 6 tests were performed in this abbreviated quality assurance test. One trend noted from the test results was that the reference method for oxygen yielded consistently higher O_2 concentrations than did the Thermox monitor. It is very possible that the Thermox monitor

TABLE 5-1. SUMMARY OF 1982 CEMS RELIABILITY

Month	Scrubber Module S-1			Scrubber Module S-2		
	Hours of FGD Operation	Hours of CEMS Operation	CEM Reliability (%)	Hours of FGD Operation	Hours of CEMS Operation	CEM Reliability (%)
January	728	661	90.8	656	594	90.5
February	283	283	100.0	539	533	98.9
March	493	490	99.4	S-2 not in service due to low loads.		
April	Plant Outage			Plant Outage		
May	415	411	99.0	265	255	96.2
June*	94	93	98.9	256	256	100.0
July	477	448	94.0	537	520	96.8
August	613	588	95.9	583	560	96.1
September	500	495	99.0	569	560	98.4
October	654	654	100.0	668	667	99.9
November	670	653	97.4	684	667	97.6
December	49	47	96.2	54	55	100.0
TOTALS	4976	4823	96.9	4811	4667	97.0

*Starting 0000 on 17 June.

may have been slightly out of calibration during the quality assurance testing, contributing, at least in part, to the lower readings. Lower O_2 values, as reported by the Thermox, will tend to lower the calculated SO_2 emission rate. However, the difference in the emission rate calculated using the Thermox and reference method O_2 values is less than 5 percent under these conditions.

Finally, to ensure the accuracy of the SO_2 and O_2 monitors, SWPP personnel periodically checked both the zero and span of the instruments using cylinder gas at known concentrations. SWPP data show that the standard deviation during these checks was only ±14 ppm SO_2, or less than 2 percent of the span gas concentration (735 ppm SO_2). In fact, the maximum SO_2 drift reported was only 29 ppm. Similarly, the O_2 standard deviation was ±0.17% O_2 or 2.8 percent of the O_2 span gas value (6.07% O_2). The maximum O_2 drift reported was 0.37% O_2.

5.4 ABILITY OF CEMS TO MEET 1979 NSPS REQUIREMENTS

The 1979 revision to the utility boiler NSPS specified SO_2 emission limits and percentage emission reductions based on a 30-day rolling average. A secondary objective of the SWPP monitoring program was to evaluate the ability of the CEMS to fulfill the data acquisition requirements of the 1979 standard. Since an inlet SO_2 monitor was not present at SWPP, SO_2 removal efficiencies could only be estimated. SO_2 emissions could be tracked, however, using the outlet SO_2 and O_2 monitors.

Thirty day averages were not calculated prior to June, when the CEMS was upgraded. SWPP operates under a 1971 standard which does not require a thirty day rolling average. Results from June to December 1982 (see Appendix C), however, indicate that the CEMS can reliably collect data to enable calculation of the thirty day average. During this period, only one day of data was invalid due to failure to capture the 18 hours of valid data required. This "lost" day was, in fact, caused by a power failure at the SWPP facility.

TABLE 5-2. RESULTS OF METHOD 6 TESTING AT SWPP ON 19 AUGUST 1982

Run No.	Time	SO_2 Concentration ppm wet		O_2 Concentration % wet			Emission Rate, lb $SO_2/10^6$ Btu		
		Reference Method[1]	CEM	Reference Method[2]	CEM	H_2O %	Reference Method	CEM	Diff.
1	10:00-10:30	279	306	6.4	5.9	1.8	0.685	0.726	-0.041
2	11:54-12:24	251	270	6.4	5.8	3.6	0.633	0.653	-0.020
3	12:57-13:27	264	250	6.3	6.0	3.6	0.661	0.613	0.048
4	13:43-14:13	277	245	6.3	5.7	7.8	0.741	0.626	0.115
5	14:30-15:00	304	287	6.6	5.8	6.5	0.815	0.725	0.090
6	15:25-15:55	298	258	6.3	5.6	5.6	0.770	0.663	0.137
						average	0.718	0.663	0.055

Confidence Interval

$$CI = \frac{t_{o.975}}{n\sqrt{n-1}} \sqrt{n\,(\Sigma x_i^2) - (\Sigma x_i)^2} = \frac{2,571}{6\sqrt{5}} \sqrt{6(0.0445) - (0.329)^2} = .076$$

Relative Accuracy

$$RA = \frac{\bar{x}_i + CI_{95}}{\text{avg. } E_{RM}} \times 100 = \frac{0.055 + 0.076}{0.718} \times 100 = 18.2\%$$

[1]EPA Reference Method 6

[2]Fyrite

SECTION 6

REFERENCES

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2. Phone conversation between David Colley, Radian Corporation, and Ken Craig, SWPP, on September 15, 1982.

3. Phone conversation between Rob Glover, Radian Corporation, and Ken Craig, SWPP, on September 15, 1983

4. Hicks, N. D., and D. M. Fraley, "Addition of Adipic and Dibasic Acids to a Conventional Flue Gas Scrubber: Costs, Operating and Design Experiences," presented at the 27th Annual American Public Power Association Engineering & Operations Workshop, San Antonio, TX, 14-17 February 1983.

5. Phone conversation between Rob Glover, Radian Corporation, and O. C. Smith, SWPP, on September 21, 1983.

6. Federal Register, 1979, New Stationary Sources Performance Standards; Electric Utility Steam Generating Units, Vol. 44, No. 113, June 11, pp. 33580-33624.

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Appendix A. SWPP Weekly Coal Analyses

SWPP 1982 COAL ANALYSIS
WEEKLY SAMPLES FROM #4 BELT

Date	Wt. % as Received					Btu/Lb	Estimated Uncontrolled Emission
	Moisture	Ash	Volatiles	Fixed Carbon	Sulfur		
01-05-82	10.5	14.0	35.0	40.4	4.5	11,263	8.0
01-12-82	9.8	15.2	34.9	40.0	3.6	11,224	6.4
01-19-82	10.0	13.0	35.6	41.4	3.5	11,463	6.1
01-26-82	9.0	11.8	36.5	42.7	3.8	11,816	6.4
Avg 1-82	9.8	13.5	35.5	41.1	3.9	11,442	6.8
02-01-82	10.3	13.6	35.6	40.5	3.7	11,293	6.6
02-09-82	-	-	-	No Sample	-	-	-
02-16-82	8.0	11.4	37.2	43.4	3.6	11,975	6.0
02-23-82	11.2	14.7	32.4	41.8	3.8	11,753	6.5
Avg 2-82	9.8	13.2	35.1	41.9	3.7	11,674	6.4
03-02-82	8.2	14.2	35.9	41.6	4.7	11,573	8.1
03-09-82	-	-	-	No Sample	-	-	-
03-16-82	7.3	11.3	35.1	46.3	3.9	12,087	6.5
03-23-82	-	-	-	No Sample	-	-	-
03-30-82	-	-	-	No Sample	-	-	-
Avg 3-82	7.8	12.8	35.5	44.0	4.3	11,830	7.3
4-82	No Samples - Unit Outage						
05-04-82	-	-		No Sample	-	-	-
05-11-82	6.0	12.7	34.0	47.2	3.7	12,208	6.1
05-18-82	9.4	15.0	31.8	43.8	2.3	11,193	4.1
05-25-82	5.8	10.9	33.7	49.6	2.6	12,612	4.1
Avg 5-82	7.1	12.9	33.2	46.9	2.9	12,004	4.8
06-01-82	8.7	10.4	34.7	45.3	2.6	12,136	4.3
06-08-82	8.1	10.6	36.5	44.8	2.7	12,240	4.4
06-15-82	8.9	13.3	35.2	42.6	3.9	11,576	6.7
06-22-82	7.1	12.8	34.0	46.2	3.0	12,047	5.0
06-29-82	8.6	12.8	36.5	42.2	3.4	11,845	5.7
Avg 6-82	8.3	12.0	35.4	44.2	3.1	11,969	5.2
07-08-82	7.9	11.8	36.3	43.9	3.5	12,015	5.8
07-13-82	8.0	12.2	36.1	43.7	3.6	11,858	6.0
07-20-82	5.9	14.0	37.6	42.6	3.8	11,708	6.5
07-27-82	7.0	11.5	38.0	43.6	3.7	12,188	6.5
Avg 7-82	7.2	12.4	37.0	43.5	3.7	11,942	6.1

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SWPP 1982 Coal Analysis, continued.
Weekly samples from #4 belt

Date	Wt. % as Received					Btu/Lb	Estimated Uncontrolled Emission
	Moisture	Ash	Volatiles	Fixed Carbon	Sulfur		
08-03-82	7.5	13.7	36.7	42.1	3.4	11,715	5.8
08-10-82	8.9	12.9	37.4	40.8	3.1	11,604	5.3
08-17-82	8.3	12.8	36.2	42.7	3.4	11,690	5.8
08-24-82	7.6	13.2	38.6	40.6	2.9	11,823	4.9
08-31-83	8.2	16.3	38.1	37.3	2.5	10,931	4.6
Avg 8-82	8.1	13.8	37.4	40.7	3.1	11,553	5.4
09-07-82	8.6	13.7	37.5	40.2	3.3	11,468	5.8
09-14-82	3.9	17.3	40.6	38.2	4.3	11,396	7.5
09-21-82	4.5	10.5	41.5	43.5	3.6	12,514	5.8
09-28-82	7.4	13.0	38.8	40.8	3.8	11,745	6.5
Avg 9-82	6.1	13.6	39.6	40.7	3.8	11,781	6.4
10-05-82	5.2	11.6	41.4	41.8	3.8	12,009	6.3
10-12-82	4.9	6.5	33.6	55.0	3.7	13,292	5.6
10-19-82	6.6	12.4	37.3	43.7	3.2	11,934	5.4
10-26-82	4.0	11.4	41.1	43.5	3.9	12,779	6.1
Avg 10-82	5.2	10.5	38.4	46.0	3.7	12,504	5.8
11-02-82	5.0	9.2	38.1	47.7	3.6	12,962	5.6
11-10-82	4.1	11.3	42.0	42.6	3.6	12,949	5.6
11-16-82	6.7	10.2	39.4	43.8	3.6	12,425	5.8
11-23-82	7.6	9.8	37.3	45.3	4.0	12,461	6.4
11-30-82	9.4	9.8	36.5	44.2	3.6	11,923	6.0
Avg 11-82	6.6	10.1	38.7	44.7	3.7	12,544	5.9

Appendix B. Summary of FGD System Performance in 1982

Date	Time	Module	DBA	pH	Fan Amps	Flue Gas Flow (1000 acfm)	L/G	Inlet SO_2 approx ppm dry 0% SO_2	Outlet SO_2 ppm, dry 0% O_2	REM
1/4	16:00	S-1	645	5.4	500	238	56.6	4800	753	84.3
		S-2	583	5.3	500	233	57.8		1029	78.6
1/7	10:45	S-1	560	5.5	460		65.5	4535	464	89.8
		S-2	565	5.4	430		82.4		544	88.0
1/12	12:30	S-1	688	5.55	560	287	47.0	3860	611	84.2
		S-2	613	5.43	510	243	55.5		694	82.0
1/15	18:00	S-1	988	5.3	545	275	49.1	3780	561	85.2
		S-2	945	5.3	510	243	55.5		644	83.0
1/19	10:45	S-1	673	5.43	540	271	49.8	3675	495	86.5
		S-2	628	5.39	510	243	55.5		543	85.2
1/22	16:00	S-1	828	5.3	530	262	51.4	3760	486	87.1
		S-2	790	5.3	480	214	63.2		568	84.9
1/28	10:45	S-1	935	5.3	540	271	49.8	3900	619	84.1
2/2	11:00	S-1	720	5.2	430	181	74.4	3920	391	90.0
		S-2	745	5.45	480	214	63.2		354	91.0
2/12	10:45	S-2	870	5.2	545	278	48.5	3690	608	83.5
2/17	18:00	S-1	880		No Fan All Day					
		S-2	718	5.2	510		55.5	3660	353	90.4
3/2	10:15	S-1	619	5.2	500	239	56.5	4890	450	90.0
3/12	16:00-17:00	S-1	1820	5.1	517	252	53.5	4170	385	90.8
3/19	19:00	S-1	1650	5.0	500	238	56.6	3800	362	90.5
5/13	12:00	S-1	649		No DART for May 12			3310	362	89.1
5/19	10:30	S-1	973	5.0	530	263	51.4	2475	381	84.6
		S-2	1105	5.0	510	243	55.5		122	95.1
5/25	11:00	S-1	1195	5.0	500	238	56.6	2480	268	89.2
		S-2	1280	5.0	450	184	73.5		119	95.2
6/3	10:30	S-1	480	4.99	437	187	72.2	4.32*	0.70*	83.8
		S-2	540	5.0	410	144	93.8		0.56	87.0
6/9	12:30	S-1	785	5.05	550	279	48.4	4.75*	0.94*	80.2
		S-2	763	5.0	480	214	63.2		0.39	91.8

*SO_2 concentrations in lb SO_2/MM Btu.

(Continued)

Date	Time	Module	DBA	pH	Fan Amps	Flue Gas Flow (1000 acfm)	L/G	Inlet SO_2 approx ppm dry 0% SO_2	Outlet SO_2 ppm, dry 0% O_2	REM
6/22	08:30	S-2	1245	5.1	560	293	46.1	3000	620	79.3
6/24	12:30	S-2	1095	5.0	550	283	47.7	3130	175	94.4
7/8	11:00	S-1	960	5.0	440	190	71.2	3510	355	89.9
		S-2	1370	5.0	445	179	75.5		380	89.2
7/13	10:45	S-1	1160	5.05	465	210	64.3	6.07*	.30*	95.1
		S-2	1395	5.05	440	174	77.7		.57*	90.6
7/15	10:45	S-1	918	5.2	520	255	53.0	3725	680	81.7
		S-2	968	5.0	410	144	93.8		455	87.8
7/20	10:45	S-1	1128	5.0	525	259	52.2	3906	295	92.4
		S-2	1310	5.0	477	211	64.1		166	95.8
7/22	10:45	S-1	920	5.0	530	263	51.4	3835	625	83.7
		S-2	1047	5.0	490	224	60.4		262	93.2
7/27	17:00	S-1	1195	5.0	520	255	53.0	3654	435	88.1
		S-2	1482	5.0	415		20.6		228	93.8
7/29	10:45	S-1	1190	4.93	510	247	54.8	3610	448	87.6
8/2	11:00	S-1	1370	5.0	560	287	47.0	3515	390	88.9
		S-2	1520	5.1	470	204	66.3		420	88.1
8/5	10:45	S-1	1100	5.1	540		49.8	3415	315	90.8
		S-2	1178	5.2	520	214	53.3		400	88.3
8/10	11:00	S-1	1020	5.1	480	222	60.8	3215	365	88.6
		S-2	1178	5.1	490	224	60.4		308	90.4
8/12	11:00	S-1	803	5.8	420	173	77.9	3295	455	86.2
		S-2	849	5.0	395	129	105.0		340	89.7
8/17	09:45	S-1	1805	5.1	510	246	54.8	3500	555	841
		S-2	1463	5.0	525	258	52.3		283	91.9
8/18	10:00	S-1	1088	5.05	510	246	54.8	5.69	560	83.6
		S-2	1027	5.1	520	253	53.3		1.00	86.9
8/24	11:00	S-1	1985	5.0	430	181	74.4	2950	175	94.1
		S-2	2060	5.0	517	250	53.9		500	83.1
8/26	14:30	S-1	1180	5.0	400	157	86.0	2896	260	91.0
		S-2	1370	5.0	410	144	93.8		310	89.3
8/31	13:00	S-1	985	540	550	279	48.4	2753	377	86.3
		S-2	955	5.0	410	144	93.8		210	92.4
9/2	11:15	S-1	1364	5.0	560	287	47.0	2956	235	92.1
		S-2	1660	5.0	510	243	55.5		182	93.8
9/7	14:00	S-1			Start Up					
		S-2	1325	5.0	490	224	60.4		249	92.8

(Continued)

*SO_2 concentrations in lb SO_2/MM Btu.

Date	Time	Module	DBA	pH	Fan Amps	Flue Gas Flow (1000 acfm)	L/G	Inlet SO_2 approx ppm dry 0% SO_2	Outlet SO_2 ppm, dry 0% O_2	REM
9/9	10:45	S-1	922	5.0	550	279	48.4	3771	700	81.4
		S-2	1098	5.0	500	233	57.8		488	87.1
9/14	11:00	S-1	1000	4.92	520	255	53.0	4541	489	89.2
		S-2	1023	5.0	500	233	57.8		591	87.0
9/16	12:30	S-2	1265	5.14	510	243	55.5	4233	600	85.8
9/21	10:45	S-1	608	5.3	485	226	59.7	3462	559	83.9
9/23	10:50	S-2	970	5.0	460	194	69.7	3585	254	92.9
9/29	11:00	S-1	1100	5.18	560	287	47.0	3882	521	86.6
		S-2	1240	5.0	510	243	55.5		395	89.8
10/5	13:00	S-1	1900	5.0	530	263	51.4	3809	432	88.7
		S-2	1910	5.0	510	243	55.5		314	91.8
10/7	11:00	S-1	630	5.45	520	255	53.0	3679	751	79.6
		S-2	728	5.1	470	204	66.3		641	82.6
10/13	11:00	S-1	1285	5.4	510	246	54.8	3332	440	86.8
		S-2	1505	5.05	490	223	60.4		500	85.0
10/14	14:00	S-1			Start Up					
		S-2	3225	5.0	490	223	60.4		210	93.7
10/19	12:15	S-1	1055	5.4	560	287	47.0	3227	605	81.3
		S-2	823	5.0	480	214	63.2		410	87.3
10/21	13:00	S-1	1460	5.2	540	271	49.8	3100	400	87.1
		S-2	740	5.05	500	234	57.8		540	82.6
10/26	15:30	S-1	880	5.4	500	239	56.6	3673	580	84.2
		S-2	1140	5.3	480	214	63.2		560	84.8
10/29	13:00	S-1	1995	5.4	428	180	75.1	3532	410	88.4
		S-2	1680	5.0	430	164	82.4		560	84.1
11/2	11:00	S-1	403	5.3	420	173	77.9	3343	505	84.9
		S-2	458	5.4	500	233	57.8		310	90.7
11/4	13:00	S-1	558	5.3	520	255	53.0	3344	295	91.2
		S-2	1885	5.42	510	243	55.5		350	89.5
11/9	11:15	S-1	795	5.4	480	222	60.8	3346	645	80.7
		S-2	820	5.4	440	174	77.7		430	87.1
11/10	12:45	S-1	730	5.4	540	271	49.8	3346	480	85.7
		S-2	575	5.4	480	214	63.2		485	85.5
11/12	14:30	S-1	478	5.4	560	287	47.0	5.65**	0.92**	83.7
		S-2	693	5.4	490	224	60.4		0.435**	92.3

(Continued)

Date	Time	Module	DBA	pH	Fan Amps	Flue Gas Flow (1000 acfm)	L/G	Inlet SO_2 approx ppm dry 0% SO_2	Outlet SO_2 ppm, dry 0% O_2	REM
11/15	11:00	S-1	918	5.28	555	283	47.7	3467	360	89.6
		S-2	807	5.18	510	243	55.5		183	94.7
11/17	13:00	S-1	665	5.4	560	287	47.0	3541	570	83.9
		S-2	652	5.4	495	228	59.1		299	91.6
11/19	13:00	S-1	782	5.4	540	271	49.8	3649	620	83.0
		S-2	721	5.4	480	213	63.2		256	93.0
11/24	12:45	S-1	1235	5.4	560	287	47.0	3831	728	81.0
		S-2	820	5.3	500	234	57.8		500	86.9
11/27	11:30	S-1	960	5.4	435	185	72.8	3733	576	84.6
		S-2	760	5.3	405	139	97.1		230	93.8

Appendix C. Continuous SO_2 Emissions Monitoring Results

RESULTS OF CONTINUOUS SO2 EMISSIONS MONITORING AT CITY UTILITIES OF SPRINGFIELD, MISSOURI FGD SYSTEM

DATE	SCRUBBER MODULE S-1					SCRUBBER MODULE S-2				
	24-HOUR EMISSION RATE	NO. OF HOURS	30-DAY AVERAGE EMISSION RATE	NO. OF HOURS	NO. OF DAYS	24-HOUR EMISSION RATE	NO. OF HOURS	30-DAY AVERAGE EMISSION RATE	NO. OF HOURS	NO. OF DAYS
16JUN82	MODULE S-1 DOWN					0.65	9			
17JUN82	MODULE S-1 DOWN					0.47	24			
18JUN32	MODULE S-1 DOWN					0.37	24			
19JUN82	1.10	23				MODULE S-2 DOWN				
20JUN82	0.68	24				MODULE S-2 DOWN				
21JUN82	0.57	8				1.32	16			
22JUN82	MODULE S-1 DOWN					0.96	24			
23JUN82	MODULE S-1 DOWN					0.30	24			
24JUN82	MODULE S-1 DOWN					0.32	24			
25JUN82	MODULE S-1 DOWN					0.56	22			
26JUN82		0	BOILER DOWN			0.46	8	BOILER DOWN		
27JUN82	MODULE S-1 DOWN					0.40	19			
28JUN82	MODULE S-1 DOWN					0.46	24			
29JUN82	0.56	14				0.31	24			
30JUN82	0.63	24				0.37	24			
01JUL82	0.33	9	BOILER DOWN			0.28	9	BOILER DOWN		
02JUL82		0	BOILER DOWN				0	BOILER DOWN		
03JUL82		0	BOILER DOWN				0	BOILER DOWN		
04JUL82		0	BOILER DOWN				0	BOILER DOWN		
05JUL82		0	BOILER DOWN				0	BOILER DOWN		
06JUL82	0.78	12	BOILER DOWN				0	BOILER DOWN		
07JUL82	0.70	23				0.73	13			
08JUL82	0.47	14				0.95	24			
09JUL32	0.58	11				0.89	24			
10JUL82	MODULE S-1 DOWN					0.85	24			
11JUL82	MODULE S-1 DOWN					1.09	24			
12JUL82	0.60	14				1.00	24			
13JUL82	0.43	18				0.59	22			
14JUL82	0.45	20				0.79	20			
15JUL82	0.77	24				0.91	24			
16JUL82	0.78	22				1.05	23			
17JUL82	0.82	24				0.73	3			
18JUL82	0.72	23				0.47	13			
19JUL82	0.68	24				0.28	23			
20JUL82	0.43	24				0.24	24			
21JUL82	0.60	24				0.27	24			
22JUL82	0.73	24	0.65	382	14	0.38	24	0.63	591	23

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RESULTS OF CONTINUOUS SO2 EMISSIONS MONITORING
AT CITY UTILITIES OF SPRINGFIELD, MISSOURI FGD SYSTEM

DATE	SCRUBBER MODULE S-1					SCRUBBER MODULE S-2				
	24-HOUR EMISSION RATE	NO. OF HOURS	30-DAY AVERAGE EMISSION RATE	NO. OF HOURS	NO. OF DAYS	24-HOUR EMISSION RATE	NO. OF HOURS	30-DAY AVERAGE EMISSION RATE	NO. OF HOURS	NO. OF DAYS
23JUL82	0.43	21	0.64	403	15	0.37	23	0.62	605	24
24JUL82	MODULE S-1 DOWN		0.64	403	15	1.04	24	0.64	605	24
25JUL82	MODULE S-1 DOWN		0.64	403	15	0.84	23	0.66	604	24
26JUL82	0.60	15	0.61	395	14	0.60	23	0.66	627	25
27JUL82	0.67	21	0.61	392	14	0.69	22	0.66	649	26
28JUL82	0.51	23	0.61	407	15	0.68	22	0.64	655	27
29JUL82	0.61	17	0.61	424	15	0.86	20	0.63	651	27
30JUL82	0.54	21	0.61	445	16	0.72	21	0.65	648	27
31JUL82	0.41	20	0.60	465	17	MODULE S-2 DOWN		0.66	624	26
01AUG82	0.64	23	0.60	488	18	0.79	14	0.67	616	25
02AUG82	0.60	19	0.60	507	19	0.88	19	0.68	616	25
03AUG82	0.68	23	0.60	530	20	0.78	24	0.70	616	25
04AUG82	0.85	24	0.61	540	21	0.83	24	0.71	616	25
05AUG82	0.89	24	0.62	540	21	1.15	22	0.74	614	25
06AUG82	0.71	24	0.62	541	21	0.82	24	0.74	625	26
07AUG82	0.52	4	0.63	531	21	1.39	22	0.76	623	26
08AUG82	0.81	13	0.63	533	21	0.28	7	0.74	606	25
09AUG82	0.89	24	0.64	557	22	0.53	24	0.73	606	25
10AUG82	0.64	23	0.64	580	23	0.60	21	0.71	603	25
11AUG82	0.74	24	0.65	590	24	0.51	22	0.69	601	25
12AUG82	1.10	24	0.67	596	24	0.98	24	0.71	603	25
13AUG82	0.93	15	BOILER DOWN			0.72	16	BOILER DOWN		
14AUG82		0	BOILER DOWN			0.95	5	BOILER DOWN		
15AUG82		0	BOILER DOWN			0.80	22	BOILER DOWN		
16AUG82	1.39	8	0.71	584	23	0.49	24	0.70	607	25
17AUG82	1.13	23	0.72	583	23	0.42	24	0.68	607	25
18AUG82	0.93	16	0.72	577	22	0.85	17	0.67	601	24
19AUG82	0.78	23	0.72	576	22	0.85	16	0.68	614	24
20AUG82	0.80	24	0.73	577	22	0.58	24	0.68	625	25
21AUG82	0.48	8	0.72	561	21	0.90	17	0.70	619	24
22AUG82	0.82	15	0.73	552	20	0.73	8	0.72	603	23
23AUG82	0.60	24	0.73	552	20	0.97	23	0.74	602	23
24AUG82	0.60	24	0.73	552	20	0.86	24	0.76	602	23
25AUG82	0.64	24	0.74	556	20	0.88	24	0.78	603	23
26AUG82	0.61	24	0.73	579	21	0.70	24	0.76	603	23
27AUG82	0.58	11	BOILER DOWN			0.78	5	BOILER DOWN		
28AUG82	0.63	24	0.73	603	22	MODULE S-2 DOWN		0.76	580	22

RESULTS OF CONTINUOUS SO2 EMISSIONS MONITORING AT CITY UTILITIES OF SPRINGFIELD, MISSOURI FGD SYSTEM

DATE	SCRUBBER MODULE S-1					SCRUBBER MODULE S-2				
	24-HOUR EMISSION RATE	NO. OF HOURS	30-DAY AVERAGE EMISSION RATE	NO. OF HOURS	NO. OF DAYS	24-HOUR EMISSION RATE	NO. OF HOURS	30-DAY AVERAGE EMISSION RATE	NO. OF HOURS	NO. OF DAYS
29AUG82	0.52	24	0.73	612	23	MODULE S-2 DOWN		0.77	557	21
30AUG82	0.88	24	0.73	615	23	0.64	17	0.77	552	20
31AUG82	0.71	24	0.74	616	23	0.50	23	0.76	553	20
01SEP82	0.71	23	0.74	622	24	0.20	24	0.74	557	20
02SEP82	0.60	22	0.75	623	24	0.24	22	0.72	558	20
03SEP82	0.56	22	0.75	625	24	0.38	24	0.71	582	21
04SEP82	MODULE S-1 DOWN		0.75	602	23	0.93	24	0.71	592	22
05SEP82	MODULE S-1 DOWN		0.76	583	22	0.73	24	0.71	597	22
06SEP82	MODULE S-1 DOWN		0.76	560	21	0.44	24	0.69	597	22
07SEP82	0.75	17	0.76	553	20	0.45	24	0.68	597	22
08SEP82	0.66	19	0.75	548	20	0.35	19	0.65	594	22
09SEP82	0.80	23	0.75	547	20	0.46	22	0.64	592	22
10SEP82	0.94	20	0.77	563	21	0.36	19	0.60	589	22
11SEP82	0.99	24	0.78	574	22	0.42	1	0.61	583	22
12SEP82	0.67	24	0.77	574	22	MODULE S-2 DOWN		0.61	559	21
13SEP82	0.78	24	0.77	575	22	0.48	15	0.60	553	20
14SEP82	0.65	24	0.77	575	22	0.62	24	0.61	555	20
15SEP82	0.53	8	0.75	559	21	0.77	24	0.60	555	20
16SEP82	MODULE S-1 DOWN		0.72	551	21	1.14	24	0.62	555	20
17SEP82	MODULE S-1 DOWN		0.71	528	20	0.93	23	0.64	554	20
18SEP82	0.96	8	0.71	520	20	1.23	16	0.66	553	20
19SEP82	0.94	24	0.71	521	20	MODULE S-2 DOWN		0.65	537	20
20SEP82	0.96	24	0.72	521	20	MODULE S-2 DOWN		0.65	513	19
21SEP82	0.90	24	0.74	537	21	MODULE S-2 DOWN		0.64	496	19
22SEP82	0.87	10	0.74	532	21	0.31	15	0.63	503	19
23SEP82	MODULE S-1 DOWN		0.75	508	20	0.43	24	0.60	504	19
24SEP82	0.83	11	0.76	495	19	0.60	24	0.59	504	19
25SEP82	0.81	24	0.76	495	19	0.57	24	0.58	504	19
26SEP82	0.73	24	0.77	495	19	0.59	24	0.57	504	19
27SEP82	0.66	24	0.77	495	19	0.49	24	0.57	528	20
28SEP82	0.67	24	0.77	495	19	0.51	24	0.56	552	21
29SEP82	0.70	24	0.77	495	19	0.56	24	0.56	559	22
30SEP82	0.79	24	0.77	495	19	0.56	24	0.56	560	22
01OCT82	0.75	24	0.77	496	19	0.70	24	0.58	560	22
02OCT82	0.79	24	0.78	498	19	0.72	24	0.60	562	22
03OCT82	0.68	24	0.78	500	19	0.84	24	0.62	562	22
04OCT82	0.90	24	0.79	524	20	0.72	24	0.61	562	22

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RESULTS OF CONTINUOUS SO2 EMISSIONS MONITORING AT CITY UTILITIES OF SPRINGFIELD, MISSOURI FGD SYSTEM

DATE	SCRUBBER MODULE S-1					SCRUBBER MODULE S-2				
	24-HOUR EMISSION RATE	NO. OF HOURS	30-DAY AVERAGE EMISSION RATE	NO. OF HOURS	NO. OF DAYS	24-HOUR EMISSION RATE	NO. OF HOURS	30-DAY AVERAGE EMISSION RATE	NO. OF HOURS	NO. OF DAYS
05OCT82	0.53	24	0.78	548	21	0.52	24	0.60	562	22
06OCT82	0.42	24	0.77	572	22	0.62	24	0.61	562	22
07OCT82	0.70	24	0.76	579	23	0.71	24	0.62	562	22
08OCT82	0.50	24	0.76	584	23	0.76	24	0.64	567	22
09OCT82	0.61	24	0.75	585	23	0.86	24	0.65	569	22
10OCT82	0.75	23	0.74	588	23	0.81	24	0.67	574	22
11OCT82	0.57	24	0.73	588	23	0.89	24	0.69	597	23
12OCT82	0.52	24	0.72	588	23	0.74	24	0.69	621	24
13OCT82	0.73	21	0.72	585	23	0.78	24	0.70	630	25
14OCT82	0.81	18	0.73	579	23	0.56	24	0.70	630	25
15OCT82	0.38	21	0.72	592	24	0.59	24	0.69	630	25
16OCT82	MODULE S-1 DOWN		0.72	592	24	0.75	11	0.68	617	24
17OCT82	MODULE S-1 DOWN		0.72	592	24	0.85	8	0.67	602	23
18OCT82	0.86	16	0.72	600	24	0.93	22	0.66	608	24
19OCT82	0.61	24	0.70	600	24	0.82	24	0.67	632	25
20OCT82	0.71	24	0.70	600	24	0.86	24	0.67	656	26
21OCT82	0.39	24	0.68	600	24	0.82	24	0.68	680	27
22OCT82	0.68	21	0.67	611	25	0.80	24	0.70	689	28
23OCT82	0.63	24	0.67	635	26	0.93	24	0.71	689	28
24OCT82	0.71	24	0.66	648	27	0.68	24	0.71	689	28
25OCT82	1.22	24	0.68	648	27	1.04	24	0.73	689	28
26OCT82	0.90	24	0.68	648	27	0.83	24	0.74	689	28
27OCT82	0.93	24	0.69	648	27	0.88	24	0.76	689	28
28OCT82	0.92	24	0.70	648	27	0.86	24	0.77	689	28
29OCT82	1.14	23	0.72	647	27	0.77	24	0.77	689	28
30OCT82	1.06	8	0.73	631	26	1.67	2	0.81	667	27
31OCT82	1.87	24	0.77	631	26	MODULE S-2 DOWN		0.81	643	26
01NOV82	1.59	20	0.80	627	26	0.60	18	0.81	637	26
02NOV82	1.06	24	0.81	627	26	0.56	24	0.80	637	26
03NOV82	0.91	24	0.81	627	26	0.78	24	0.80	637	26
04NOV82	0.87	24	0.82	627	26	0.81	24	0.81	637	26
05NOV82	0.91	23	0.84	626	26	0.68	23	0.81	636	26
06NOV82	0.77	22	0.84	624	26	0.43	22	0.81	634	26
07NOV82	0.67	9	0.85	609	25	1.05	19	0.82	629	26
08NOV82	0.53	13	0.85	598	24	0.95	23	0.82	628	26
09NOV82	1.20	22	0.86	597	24	0.76	24	0.82	628	26
10NOV82	0.81	24	0.87	597	24	0.73	24	0.81	628	26

RESULTS OF CONTINUOUS SO2 EMISSIONS MONITORING
AT CITY UTILITIES OF SPRINGFIELD, MISSOURI FGD SYSTEM

DATE	SCRUBBER MODULE S-1					SCRUBBER MODULE S-2				
	24-HOUR EMISSION RATE	NO. OF HOURS	30-DAY AVERAGE EMISSION RATE	NO. OF HOURS	NO. OF DAYS	24-HOUR EMISSION RATE	NO. OF HOURS	30-DAY AVERAGE EMISSION RATE	NO. OF HOURS	NO. OF DAYS
11NOV82	0.81	21	0.88	594	24	0.73	24	0.81	628	26
12NOV82	0.93	15	0.89	588	23	0.60	24	0.80	628	26
13NOV82	0.71	24	0.89	594	23	0.48	24	0.80	628	26
14NOV82	0.68	24	0.90	597	23	0.52	24	0.80	628	26
15NOV82	0.67	19	0.89	616	24	0.42	19	0.79	636	27
16NOV82	0.61	24	0.88	640	25	0.36	24	0.77	652	28
17NOV82	0.86	24	0.88	648	26	0.51	24	0.76	654	28
18NOV82	0.72	22	0.88	646	26	0.39	24	0.74	654	28
19NOV82	1.01	16	0.89	638	25	0.43	24	0.73	654	28
20NOV82	0.53	24	0.90	638	25	0.32	24	0.71	654	28
21NOV82	0.80	24	0.90	641	25	0.41	24	0.70	654	28
22NOV82	0.82	24	0.91	641	25	0.53	24	0.68	654	28
23NOV82	1.00	24	0.92	641	25	0.55	24	0.68	654	28
24NOV82	1.08	24	0.91	641	25	0.52	24	0.66	654	28
25NOV82	0.90	24	0.91	641	25	0.57	24	0.65	654	28
26NOV82	1.42	24	0.93	641	25	0.71	24	0.64	654	28
27NOV82	0.87	22	0.93	639	25	0.43	17	0.63	647	27
28NOV82	0.88	16	0.92	632	24	1.02	7	0.64	630	26
29NOV82	0.96	24	0.92	648	25	0.67	18	0.60	646	27
30NOV82	0.62	24	0.87	648	25	0.72	24	0.61	670	28
01DEC82	0.81	24	0.85	652	25	0.90	24	0.62	676	28
02DEC82	0.41	16	BOILER DOWN			1.06	17	BOILER DOWN		
03DEC82	0.37	7	BOILER DOWN			1.00	14	BOILER DOWN		

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APPENDIX D

EMISSION MONITORING RESULTS FOR 1983

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Appendix D. Emission Monitoring Results for 1983

DATE	24 HOUR AVERAGE	BOILER HOURS
5/19	1.5	10
5/20	2.0	24
5/21	1.0	24
5/22	1.0	24
5/23	0.9	24
5/24	1.0	24
5/25	1.1	24
5/26	0.9	24
5/27	1.2	24
5/28	1.6	24
5/29	0.3	7
5/30	0.0	0
5/31	1.2	16
6/1	0.8	24
6/2	1.0	24
6/3	0.8	24
6/4	0.8	24
6/5	0.9	24
6/6	1.0	24
6/7	1.0	24
6/8	1.0	24
6/9	1.0	24
6/10	1.3	24
6/11	0.8	24
6/12	0.6	24
6/13	0.8	24
6/14	0.5	24
6/15	0.7	24
6/16	0.7	24
6/17	0.8	12
6/18	0.0	0
6/19	0.0	0
6/20	0.0	0
6/21	2.4	23
6/22	1.2	24
6/23	1.2	24
6/24	1.0	24
6/25	0.8	24
6/26	0.6	24
6/27	0.8	24
6/28	0.9	24
6/29	1.6	23
6/30	1.0	24

EMISSION MONITORING RESULTS FOR 1983

DATE	24 HOUR AVERAGE	BOILER HOURS
7/1	1.1	24
7/2	0.8	24
7/3	1.0	24
7/4	1.0	24
7/5	0.7	14
7/6	0.0	0
7/7	1.2	15
7/8	0.9	24
7/9	0.9	24
7/10	0.9	24
7/11	1.0	24
7/12	0.9	24
7/13	1.0	24
7/14	0.8	24
7/15	0.8	24
7/16	0.8	24
7/17	0.8	24
7/18	1.0	24
7/19	0.8	24
7/20	1.0	24
7/21	0.7	24
7/22	0.6	24
7/23	0.6	24
7/24	0.5	24
7/25	0.6	24
7/26	0.7	24
7/27	0.7	24
7/28	1.0	24
7/29	0.9	24
7/30	0.7	24
7/31	0.5	24
8/1	0.8	24
8/2	0.7	24
8/3	1.2	24
8/4	0.9	24
8/5	0.8	24
8/6	0.5	24
8/7	0.7	24
8/8	0.8	24
8/9	1.1	24
8/10	1.2	24
8/11	0.8	24
8/12	0.7	24
8/13	0.7	24

EMISSION MONITORING RESULTS FOR 1983

DATE	24 HOUR AVERAGE	BOILER HOURS
8/14	0.6	24
8/15	0.9	24
8/16	0.1	3
8/17	0.0	0
8/18	1.0	10
8/19	0.8	24
8/20	0.7	24
8/21	0.6	24
8/22	0.7	24
8/23	0.9	24
8/24	0.9	24
8/25	0.3	13
8/26	0.0	0
8/27	0.0	0
8/28	0.0	0
8/29	0.1	1
8/30	1.7	24
8/31	0.9	24
9/1	1.0	24
9/2	0.9	24
9/3	1.0	24
9/4	0.9	24
9/5	0.9	24
9/6	0.6	24
9/7	0.6	24
9/8	0.6	24
9/9	0.6	24
9/10	0.9	24
9/11	0.7	24
9/12	0.9	24
9/13	1.0	24
9/14	0.8	24
9/15	1.0	24
9/16	0.7	24
9/17	0.3	24
9/18	0.5	24
9/19	0.6	24
9/20	0.8	24
9/21	0.8	24
9/22	0.9	24
9/23	0.8	24
9/24	0.8	24
9/25	0.8	24
9/26	0.8	24

EMISSION MONITORING RESULTS FOR 1983

DATE	24 HOUR AVERAGE	BOILER HOURS
9/27	0.8	24
9/28	0.8	24
9/29	0.8	24
9/30	0.8	24
10/1	0.8	24
10/2	0.8	24
10/3	0.9	24
10/4	0.8	24
10/5	0.8	24
10/6	0.8	24
10/7	1.3	19
10/8	0.0	0
10/9	0.0	0
10/10	0.0	0
10/11	0.0	0
10/12	0.0	0
10/13	0.0	0
10/14	0.0	0
10/15	0.0	0
10/16	0.0	0
10/17	0.0	0
10/18	0.0	0
10/19	0.0	0
10/20	0.0	0
10/21	0.0	0
10/22	0.0	0
10/23	0.0	0
10/24	0.0	0
10/25	0.0	0
10/26	0.0	0
10/27	0.0	0
10/28	0.0	0
10/29	0.0	0
10/30	0.0	0
10/31	0.0	0
11/1	1.4	14
11/2	0.9	19
11/3	0.0	0
11/4	0.0	0
11/5	0.0	0
11/6	0.0	0
11/7	0.0	0
11/8	0.0	0

EMISSION MONITORING RESULTS FOR 1983

DATE	24 HOUR AVERAGE	BOILER HOURS
11/9	0.0	0
11/10	0.0	0
11/11	0.0	0
11/12	0.0	0
11/13	0.0	0
11/14	1.5	14
11/15	0.9	24
11/16	0.9	11
11/17	0.0	0
11/18	0.0	0
11/19	0.0	0
11/20	0.0	0
11/21	1.1	11
11/22	1.0	7
11/23	0.0	0
11/24	0.0	0
11/25	0.0	0
11/26	0.0	0
11/27	0.0	0
11/28	0.0	0
11/29	0.0	0
11/30	0.0	0
12/1	0.0	0
12/2	0.0	0
12/3	0.0	0
12/4	0.0	0
12/5	0.0	0
12/6	0.0	0
12/7	0.0	0
12/8	0.0	0
12/9	0.0	0
12/10	0.0	0
12/11	0.0	0
12/12	0.0	0
12/13	0.0	0
12/14	0.0	0
12/15	0.0	0
12/16	0.0	0
12/17	1.7	6
12/18	3.5	24
12/19	1.3	24
12/20	1.2	24
12/21	1.9	24
12/22	0.9	24

EMISSION MONITORING RESULTS FOR 1983

DATE	24 HOUR AVERAGE	BOILER HOURS
12/23	---	---
12/24	0.9	24
12/25	1.0	24
12/26	0.9	24
12/27	0.8	24
12/28	0.9	24
12/29	1.2	24
12/30	1.1	24
12/31	0.6	24